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AN INVESTIGATION OF THE FEASIBILITY OF IMPLEMENTING
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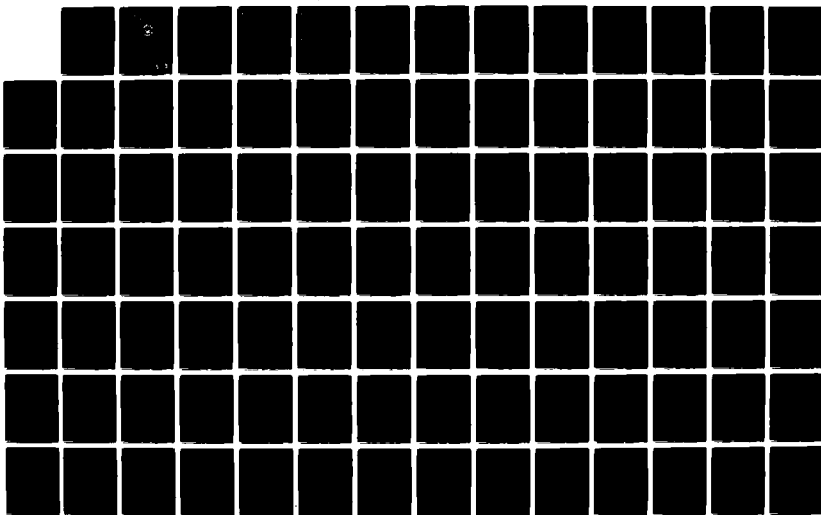
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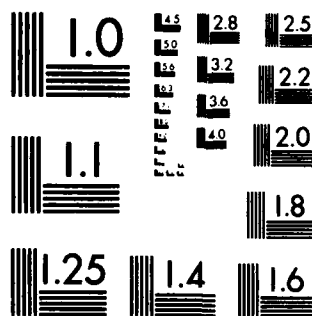
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Monterey, California



THESIS

AN INVESTIGATION OF THE FEASIBILITY OF
IMPLEMENTING SUBSTANTIAL FINITE ELEMENT
CODES ON POPULAR MICRCCOMPUTERS

by

David Joseph Mulholland

October 1982

Thesis Advisor:

G. Cantin

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An Investigation of the Feasibility of
Implementing Substantial Finite Element
Codes on Popular Microcomputers

by

David Joseph Mulholland
Lieutenant, United States Navy
B.S.M.E., University of Utah, 1975

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The size and cost of microcomputers continue to decrease while their memory capacity and execution speed increase. These advances should result in small, inexpensive machines attaining the same computing power as current mainframe models. The interim need is to adapt general finite element codes to present day, less capable microcomputers. This thesis explores the program structure, memory management, I/O procedures and equation solving methods necessary to accomplish that task. The equation solving capacity and speed of the Apple-II Plus Personal Computer Systems and the Hewlett-Packard System 45(A) Desktop Computer are compared. A finite element program for the static analysis of space trusses is presented, as adapted to and tested on the Apple-II Plus. The program output may be printed in either English or French.

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I. INTRODUCTION

A. PURPOSE AND SCOPE OF THE INVESTIGATION

In the preface of the third edition of his classic reference on the finite element method, Zienkiewicz [1] made an assessment of the "state-of-the-art" of this most useful analytical technique. In 1977, Zienkiewicz described a discipline which had amassed a collection of nearly 8000 published reference works in an ever widening variety of applications, and which had evolved far beyond its roots as an engineering tool for linear analysis of solid mechanics structures. Present applications commonly include heat transfer, fluid mechanics and non-linear solid mechanics, as well as the complete static and dynamic analysis of engineering structures.

A more general statement may be made [1] in describing the finite element method as "... a general discretization procedure of continuum problems, posed by mathematically defined statements." The method now becomes the means of approximating a continuous problem with a discrete model composed of finite elements, as opposed to "infinitesimal" elements in the sense of the calculus. In some cases, in the limit, as the number of elements increases to infinity and the physical dimensions these elements represent decrease, the solution of the model becomes exact. It is this generality of method

and application which has been one of the two most important factors influencing the widespread use of the method in scientific research and industrial applications.

The second factor influencing the spread of the finite element method has been the availability of high speed, high capacity, general purpose digital computers. It is well known that the method remained in its infancy until general purpose digital computers became available in reasonable numbers. Today technological advances in microelectronics and solid state devices have drastically reduced the real cost of computer time. Advances in the art of building static, random access memory now allow the use of Direct Memory Access techniques in small (16+ bit word) desktop machines. When these machines are interfaced with magnetic hard disk drives, a small user easily has the potential of 16 Megabytes (8 binary bits equals one byte) of high speed storage, at a small fraction of the cost of a large main-frame computer [2]. These developments are truly revolutionary. Very "friendly" and general structural finite element codes, some with appealing interactive graphics capabilities, may soon become available to the smallest of organizations.

In addition to the new machines now on the horizon, there are a very large number of smaller, less capable computers presently in service. These smaller machines, often described as "microcomputers," vary in word length and storage

capacity, generally having from 16 to 256 thousand bytes of random access memory. They support a wide variety of peripheral equipments, the most indispensable of which are high speed, magnetic disk drives.¹ These smaller machines are proportionately less expensive than larger computers, which accounts for the very great demand for these systems in industry, government and the private sector. Many of the most popular models began as "personal" or leisure computers for hobbyists, but rapidly moved into small business, medical and financial management applications as the utility of the machines was realized and software became available.

If one looks, however, for finite element software or attempts to find evidence of this widespread analytical technique being implemented in any substantial manner on microcomputers, the results are disappointing. It is the thesis of this investigation that:

(1) Substantial problems in finite element analysis can be solved on microcomputers.

(2) Microcomputers can solve substantial finite element problems with acceptable accuracy and to reasonable precision.

¹ Disk storage extends the usefulness of microcomputers by avoiding or softening the impact of some of the limits imposed by having too little main "core" memory.

(3) Although the central processor clock speed of most popular microcomputers is much less than that of a mainframe computer, and in spite of the interpretive nature of most microcomputer languages, substantial finite element problems can be solved on these machines in an acceptable amount of time.

(4) General guidelines can be established for using innovative program structuring, memory management, software overlay schemes, data base management and high speed, disk storage to allow the implementation of substantial finite element codes on small popular microcomputers.

B. CHOICE OF MACHINES AND PERIPHERAL DEVICES

The choice of machines was influenced most heavily by the types of systems available at the Naval Postgraduate School. A Hewlett-Packard System 45 Desktop Computer was available within the Mechanical Engineering Department and was a logical first choice. Previous work had already been done on implementing a finite element code on this system [3] and the potential existed for increasing the capabilities of the program by adding additional finite elements, changing from an "in-core" to an "out-of-core" equation solver, and using magnetic floppy disk instead of magnetic cartridge tape mass storage. These systems are not uncommon within the Department of Defense and the Navy and the potential benefit from an improved program was judged to be worth the additional effort which would be required to upgrade the code.

The System 45 is, however, nearly outside the boundaries of the group of machines previously described as "popular microcomputers." The base price of the computer alone, exclusive of the disk drives, was over \$29,000.00 in 1977. A new System 45 (HP 9845C), upgraded and having slightly more computing capability, would have cost about \$39,500.00 if purchased in 1980 [4] and still be without disk mass storage. It was decided, therefore, to also choose a system which would represent those on the lower end of the cost spectrum. Several Apple-II Plus² Personal Computer Systems were available, having a total price, including multiple disk drives, of approximately \$6,000.00. In addition to having a low cost, the Apple-II Plus systems also had the capability of the FORTRAN Language Option, not available on the HP 9845A.

For the reasons enumerated above, it was decided to investigate the equation solving capability of the Apple-II Plus Personal Computer and the Hewlett-Packard System 45 Desktop Computer (HP 9845A) and to attempt, should adequate time be available, the installation of representative finite element codes on both systems.

1. The Hewlett Packard 9845 Desktop Computer

The System 45 was, in 1980, the top-of-the-line model of Hewlett-Packard desktop computers. As with all of this

² Apple-II Plus is a registered trademark of the Apple Computer Company.

firm's computers, technical details about the hardware are closely held by the company and few are available in users manuals supplied with the machine or in the Hewlett-Packard Journal. References [5] and [6] and the installation documents for the system provided the information necessary to conduct the investigation.

Only a very brief summary of the most important details appears in the following sections, and readers intending to use programs presented in this thesis must become familiar with the machine in general and their own systems in particular.

a. System Configuration

The system configuration during the investigation is shown in the table below. Only the minimum devices and options which are required to run the program presented in this thesis are shown. Note that the possession of a more capable system than the one shown (e.g. one hard disk instead of dual flexible disk drives) will not preclude use of the proposed software. The reader need only change the "mass storage unit specifier" [6] and "select" [5] codes to match his/her particular configuration.

Although, under the "unified mass storage concept" [5], it is possible for a user to substitute cartridge tape for disk mass storage in nearly any program, this practice is unsuitable for solution of large systems of linear equations out-of-core. Previous experience with less demanding mass storage tasks [4] showed degradation of system

performance, on large problems, where tapes were required to rewind too many times. Stretching of the tape initially introduced parity errors and later caused breakage of the tape.

Table 1: Configuration of the Hewlett-Packard Systems 45 Installation

Required Devices:

Part No.	Description	Remarks
HP 9845A	Computer with CRT	
HP 98032A	16 Bit Interface (9885A Disk)	Option 85
HP 9885M	Flexible Disk Drive (Master)	Drive 0
HP 9885S	Flexible Disk Drive (Slave)	Drive 1

Required Options:

Number	Description	Remarks
203	64K RAM	
310	Mass Storage ROM	
320	I/O ROM Left	
330	I/O ROM Right	
370	Graphics ROM	Select Code 13
500	Internal Thermal Printer	Select Code 0

Select Code Summary:

Code	Device
0	Printer
8	Flexible Disk Drive (Controller)
13	Graphics ROM
16	CRT Display

b. Machine Precision

The HP9845A stores floating point numbers between $9.9999999999 \times 10^{99}$ and 1×10^{-99} in absolute value. An extended calculation range of $9.9999999999 \times 10^{511}$ to 1×10^{-511} is used for the results of intermediate calculations [5]. Floating point numbers are described as full precision or short precision. Full precision floating point variables each occupy 8 bytes of storage and are used exclusively in all HP Enhanced BASIC Programs presented in this thesis.

Chapter 3 of Reference [7] discussed the estimation of machine roundoff error (as part of a discussion on estimating the relative error in the solution of systems of linear equations from the matrix condition number). The worst case roundoff error, in base 10 for a 12 digit machine is:

$$10^{-12+1} = 0.000000000001$$

Section 2.2 of Reference [7] also defines a quantity called the machine epsilon as the smallest floating point number distinguishable from zero. A program, modeled after that presented in the reference, found the machine epsilon of the HP9845 to be $7.27595761415\text{E}-12$.

c. The Enhanced BASIC Language

The Enhanced BASIC Language from Hewlett-Packard has all the features of the most powerful, high level versions

of BASIC (Beginners All-purpose Symbolic Instruction Code) and certain extensions designed to provide optimum use of the System 45. References [5] and [6] contain a complete description of the language and references for further study.

As with most versions of microcomputer BASIC, the language is completely interpretive in nature. That is, no compilation or conversion of source code to machine language is accomplished before executing the program. Each line of source code is interpreted, line-by-line, as execution progresses. Although this makes it possible for the program to have such incredible flexibility as to be able, in some cases, to edit itself during execution, it also considerably slows the speed of execution. On the positive side, it is true that there are many instructions in Hewlett-Packard Enhanced BASIC which can reduce the amount of source code required over, say, the same program in FORTRAN (e.g., the MAT series of instructions for matrix manipulation [5]).

The reader who is familiar with FORTRAN will have little trouble following the programs presented in this thesis. The table below lists some of the more unusual features of the language and should be enough to allow complete understanding of program flow. For further information, the reader must consult the references given above.

Table 2: Selected Members of the Hewlett-Packard
Enhanced BASIC Instruction Set

Definitions:

"filename" is a numeral or numeric expression having an integer value between 1 and 10.

"file specifier" is a character string enclosed in quotation marks or a string variable which is a valid and complete file name (including mass storage unit specifier).

Statements:

ASSIGN# filename TO file specifier

The ASSIGN statement places the filename in an internal table and allows the file to be referenced by a single integer number in PRINT# or READ# statements [5].

BUFFER# filename

Sets up an additional 256 byte I/O buffer for all READ# and PRINT# statements to the specified filename, allowing the most efficient coupling between a file and its associated mass storage device [6].

OPTION BASE 1

Specifies that the lower bound of all array variable subscripts shall be 1 (e.g. Vector (1) is allowed but Vector (0) is not) [5].

Yyy = FNxxxxx (aa, B,Ccc,...)

Call to a function subprogram previously defined by a DEF FNxxxxx statement [5]. In FORTRAN this would be YYY = XXXXXX (AA,B,CCC,...) where XXXXXX is a FUNCTION subprogram or an intrinsic function set up with a statement function definition.

Zzz000:

An example of a label to which program flow may be transferred and which keeps its relative position within the file regardless of changes in line numbering [5]. Any proper statement may follow the colon.

BEEP

Causes a tone to be sounded at the keyboard [5].

DISP "Character string"

Causes the character string enclosed in quotation marks to be printed in the display area of the CRT [5].

OVERLAP

Allows computation and I/O to occur simultaneously. Most beneficial when a program has nearly equal amounts of computation and I/O. This mode is disabled by the SERIAL statement. See [5] and its references for a discussion of the OVERLAP statements impact on error traps.

When attempting to reduce the run time of a program, it is important to recall the method used by the HP9845 when a subroutine or function call, or transfer to a statement label or line number, is encountered. The BASIC interpreter jumps to the beginning of the file whenever a search for one of these items is instituted. Run speed can be improved significantly when the most frequently used functions and subroutines are placed as near to the beginning of a long program as possible. Note also that comment lines in BASIC (statements preceeded by REM or an exclamation point) are now a liability because they increase the length of a program. The amount of documentary comments should be limited to the minimum necessary to understand the code.

It is possible to overlay subroutines, by using the LINK statement, at any line number in the main program (or in place of the main program if desired) [5]. Overlaying reduces the amount of program in core, allowing the storage of more variables or the execution of programs too large to fit in memory in a single piece.

d. Disk Mass Storage Considerations

The characteristics of the disk mass storage hardware used with any microcomputer have a significant impact on the performance of the system in finite element calculations. The size and number of usable physical records on the disk, size of the file directory available and types of file structure and access allowed are all important considerations in attaining optimum use of out of core storage.

In the HP 9845 there are two types of records with which the programmer must be concerned [6]. A physical record is the unit of storage dealt with by the mass storage device itself (and is usually the buffer size associated with the device). Defined records are the smallest addressable units of storage, in even numbers of bytes, which can be individually accessed by the user. Whenever possible the defined record length should match the physical record length of the device in use. In the HP 9845 this matching of record lengths can provide an improvement in I/O performance of two- or three-to-one.

Reference [6] describes the use of binary DATA files and Direct Memory Access (data transfer without the use of buffers) for the rapid transfer of entire arrays between disk mass storage and core memory. This method can result in a considerable I/O improvement over buffering techniques, depending on the storage device and the amount of data to be accomplished.

The characteristics of the HP 9885 Flexible Disk Drive are listed in the table below.

Table 3: Selected Characteristics of the Hewlett-Packard 9885 Flexible Disk Drive

Storage Capacity:	
Bytes (total)- - - - -	499,200
Physical records (maximum) - - - - -	1,950
Physical records (useable) - - - - -	1,901
Files (Director size limit)- - - - -	352
Bytes per physical record - - - - -	256
Accessing:	
Maximum transfer rate (bytes per second) - - -	46,000

2. The Apple-II Plus Personal Computer

The Apple-II Plus Personal Computer is manufactured by Apple Computer Incorporated of Cupertino, California and is designed around the MOS Technology 6502 microprocessor. The maximum addressing range is 2^{16} (64K) locations on a 16 bit parallel bus. The data bus is 8 bits, parallel and bi-directional and the CPU clock speed is 1.203 MHz. More technical information is available in Reference [8].

a. System Configuration

The baseline Apple-II Plus central processor does not vary appreciably from installation to installation, although enterprising companies have recently marketed accessories which can actually replace the 6502 microprocessor with the more popular 280 CPU (and/or increase the clock

speed). The possible systems, however, and the languages available on those systems are too numerous to mention. One special purpose and six general purpose "slots" are available at the rear of the computer for connection of peripheral devices. These slots are supplied power and have access to all data bus, address bus, control and interrupt lines.

The table below describes the configuration of the system used in this investigation.

Table 4: Configuration of the Apple-II Plus Personal Computer Installation

Hardware:

No. used	Device	Remarks
1	Apple-II Plus	48K RAM
1	Apple Language System	16K RAM
2	Apple Disk-II Interface Card	
4	Apple Disk-II Floppy Disk Drives	
1	Apple Parallel Printer Interface Card	
1	Microline-80 Dot Matrix Graphics Printer	
1	Sony Trinitron Color Video Monitor	

Software:

Apple FORTRAN
Apple Pascal

Slot Connections:

Slot No.	Device	Remarks
0	Language System Card	
1	Printer Interface Card	
5	Disk-II Interface Card	Volumes 11 and 12
6	Disk-II Interface Card	Volumes 4 and 5

b. Machine Precision

The Apple-II Plus stores floating point numbers between $1.7 \times 10^{+38}$ and 5.8×10^{-38} in absolute value and

integer numbers between +32,768 and -32,768 [8]. Floating point variables each occupy 4 bytes (two machine words) of storage and integer variables occupy 2 bytes (one word).

The bit allocation for a floating point number is:

Bit:	31	30 . . . 23	22 . . . 16 and 15 . . . 0
Item:	sign	exponent	mantissa

Floating point variables having a maximum of 6 decimal digits may be stored.

Using the methods of chapter 3 of reference [7], the estimate of worst case roundoff error is:

$$10^{-6+1} = 0.00001$$

The machine epsilon (smallest floating point number distinguishable from zero) was investigated using the program of section 2.2 of reference [7] and was found to be .119209E-06.

c. The Apple FORTRAN Language and the Pseudo Machine References [9] and [10] discuss the Apple FORTRAN³ language and explain its implementation on the machine and relation to the Apple Pascal Operating System. Although it is not necessary to know any Pascal to operate the system and use Apple FORTRAN, from a user point of view it is helpful to remember that this version of FORTRAN was implemented

³ Apple FORTRAN is a registered trademark of the Apple Computer Company.

exclusively for use with the operating system. When using the Apple-II described in this thesis, the user is really working on a virtual or "pseudo" machine which has been created by the operating system. This is best thought of as a software generated device which emulates the familiar hardware (e.g., registers) found in a real computer.

The machine language of this virtual microcomputer is "pseudo code" (p-code) which resembles a true machine language. P-code is, supposedly, portable among all computers which operate under any version of University California, San Diego, Pascal (UCSD Pascal).⁴ This would also require that the mass storage medium upon which the program is stored and the format of storage be compatible with both machines (e.g. an Apple-II 5 inch floppy disk is not a compatible storage medium with the IBM 3033 at the Naval Postgraduate School). A p-code interpreter program, which is a true machine language program and is therefore computer dependent converts the p-code to (in the Apple-II case) 6502 instruction codes. All other programs, including the operating system itself, are in p-code.

⁴ UCSD Pascal is a registered trademark of the Regents of the University of California. Use thereof in conjunction with any goods or services is authorized by specific licence only and is an indication that the associated product or service has met quality assurance standards prescribed by the University. Any unauthorized use thereof is contrary to the laws of the State of California.

It is clear then how the FORTRAN Language option works on the Apple-II Plus. The Apple FORTRAN Compiler is a p-code program which reads TEXT files having proper FORTRAN syntax and in turn creates from them a pseudo CODE file which is compatible with the virtual machine. It is also clear that Pascal and FORTRAN routines can be mixed, through linking, into a single executable CODE file. One of the original advantages of this microcomputer system was that FORTRAN was available and that the great volume of scientific program which are currently in the literature were potentially adaptable to the Apple-II. The author considered that the need to use Pascal would nullify this advantage. Unless the reader desires to use the Pascal unit presented in Appendix A of this thesis, the Pascal language need not be mentioned again.

The "proper" FORTRAN syntax mentioned above is described in detail in Reference [9]. Apple FORTRAN is based on the American National Standard Programming Language FORTRAN ANSI X3.9-1978⁵ (popularly known as ANSI subset FORTRAN 77). There are certain deviations from the standard, both deficiencies and extensions, which are adequately discussed in [9].

⁵ Available from the American National Standards Institute, Inc., 1430 Broadway, New York, New York, 10018.

Readers familiar with FORTRAN will have no trouble following the programs given in this thesis. Some specialized statements, called compiler directives, will be unfamiliar to most users but are discussed in detail in Appendix A. Input/Output statements will briefly be discussed in the next section.

Double precision calculations are not possible in Apple FORTRAN as it is presently implemented.

d. Disk Mass Storage Considerations

Physical records on the Apple-II diskette are called blocks and each consist of 512 bytes. Page 25 of Reference [10] contains a discussion of the technical details of the diskette and its storage format and is summarized in the table below:

Table 5: Selected Characteristics of the Apple Disk-II Flexible Disk Drive

Storage Capacity:	
Bytes (total) - - - - -	143,360
Tracks- - - - -	35
Sectors - - - - -	16
Physical records/blocks (maximum) - -	280
Physical records/blocks (usable)- - -	274
Files (Directory size limit)- - - - -	77

Disk files on the Apple-II may be any combination of sequential or direct access and formatted or unformatted. The OPEN statement in Apple FORTRAN corresponds to the more familiar DEFINE FILE statement. The format of the OPEN statement is:

```
OPEN (u,FILE=fname [,ACCESS='string1']  
+ [,STATUS='string2'] [,FORM='string3']  
+ [,recl=r1])
```

,where,

OPEN (u

is required and must appear as the first argument and "u" may be an integer variable or expression.

,FILE=fname

is required and must appear as the second argument and fname is a CHARACTER expression of the complete file name (including disk, name and type extension).

,STATUS='string1'

is optional and 'string1' must be one of the CHARACTER constants 'OLD' or 'NEW' (the default is 'OLD').

,ACCESS='string2'

is optional and 'string2' must be one of the CHARACTER constants 'SEQUENTIAL' or 'DIRECT' (the default is 'SEQUENTIAL').

,FORM='string3'

is optional and 'string3' must be either the CHARACTER constant 'FORMATTED' or 'UNFORMATTED' (the default is 'FORMATTED').

,RECL=rl

required and only allowed for direct access files where "rl" is an integer variable or expression.

One serious limitation is present when using direct access files in Apple FORTRAN with the Pascal Operating System. When locating data in the direct access diskette file, the system apparently uses the record number and record length given by the user to compute the number of the bytes from the beginning of the file to the data to be read or written. Since the largest integer which may be represented in the machine is 32,768, this is the maximum number of bytes which may be present in a direct access file. For single direct access files the maximum number of records is $(32768 / RECL)$, so that for the optimum record length of 512 bytes, a direct access file may be at most 64 blocks long.

II. COMPARATIVE SYSTEM TESTING USING OUT OF CORE LINEAR EQUATION SOLVERS

The key factor in determining the suitability of a particular microcomputer system for solving finite element problems is the machine's facility for solving systems of simultaneous, linear, algebraic equations. It was decided that, before proceeding with the installation of a code on either chosen microcomputer, a standard test should be devised to ensure that reasonably large systems of equations could be solved. As a point of interest, it was also desired to compare the relative speeds of the two machines, although neither would be excluded from the study solely because of low solution speeds. Since microcomputers are so much less expensive than larger computers, the relative cost of CPU time is also proportionately much lower, and a slow machine which is sufficiently accurate and has the capability of handling a program large enough for a variety of element types, remains acceptable. Before discussing the choice of solution methods used in the testing, it is helpful to recall the source and characteristics of the systems of equations to be solved.

A familiar and most common method of finite element analysis is the displacement based method (see, for example, [12]) which gives rise to a system of constant coefficient differential equations of the form:

$$M \ddot{U} + C \dot{U} + K U = F$$

,where,

M is the constant coefficient, mass matrix of the finite element structure and usually considers the element mass as a consistent, equivalent masses lumped at appropriate nodes.

C is the constant coefficient, damping matrix of the finite element structure. The coefficients of this matrix are frequency dependent and are best determined from the assembled mass and stiffness matrices and consideration of experimental results [12].

K is the constant coefficient, stiffness matrix of the finite element structure. This matrix is, in the direct stiffness method, assembled from element stiffness matrices, which in turn are developed from strength of materials considerations and the geometry of the chosen element type.

U is a matrix of time dependent, global, nodal displacements in the degrees of freedom appropriate for the element type chosen and the physical structure that the element assemblage represents. The coefficients in \dot{U} and \ddot{U} are understood to be the global, nodal velocities and accelerations, respectively.

F is a matrix of consistent, applied forces acting in the global degrees of freedom and arising from body, surface and concentrated forces applied to the element structure and from initial stresses (e.g. thermal or "lack-of-fit" pre-stresses). In the most general case, these forces will also be functions of time.

For static analysis M and C effects are disregarded and:

$$K U = F$$

,where, the entries of U and F are independent of time and the system of differential equations reduces to a system of linear algebraic equations. An over simplified, but helpful way to understand this system is to recall a simple Newtonian summation of forces, including D'Alembert's dynamic forces, on a single mass (i.e., $F = ma$); the two situations are analogous, the finite element system being more general and most powerful. Even when dynamic effects are considered, direct integration methods [12] are most often used and require only the solution of the general form at various instances in time, such that one is again solving a linearized algebraic system. The equations produced by the above method have several desirable properties [12-14].

Firstly, the system of equations is generally well conditioned and positive definite [14]. For this class of

problem Gaussian elimination or equivalent techniques (e.g. see LDL^T factorization in [12]) are the most efficient and stable [13].

Secondly, the system is symmetric, such that the matrix of coefficients has the appearance of having been reflected about the main diagonal. In the interests of reducing the number of arithmetic operations and the storage required for solution, only the main diagonal and all entries above (or below) need be considered. This is the most easily programmed improvement over full Gaussian elimination and requires the least amount of additional code [13].

Thirdly, the coefficient matrices are sparse and tightly banded, if proper techniques of nodes numbering are used [12, 14]. Sparsity means there are a large number of zeros in the off-diagonal entries of the matrix and bandedness means that most non-zero entries are concentrated near the main diagonal. With some additional code, the solution algorithm can be designed to store and work only with elements "below the skyline" of the matrix [12], and to have some reduction in storage requirements and solution times. Note, however, that for smaller systems of equations and for microcomputers, this reduction in storage is somewhat offset by the additional code required. With an interpretive language such as BASIC, some of the speed advantage is also offset when this additional code must be repeatedly read.

Since the exactness of the finite element solution depends in the large part on the fineness of the mesh (greatest possible number of discrete elements to model the continuous real system), it is not uncommon for a practical problem to have from hundreds to tens-of-thousands of elements [12]. No computer presently in use can solve the largest problems by having the entire system of equations in core throughout the entire solution phase. Most new, general purpose codes work with out-of-core solution of equations and store the majority of the system on magnetic disk or tape as part of a more complete problem database. Any useful algorithm must be capable of solving large numbers of equations, efficiently, out-of-core.

A. CHOICE OF EQUATION STORAGE SCHEME AND SOLUTION ALGORITHM

For the purposes of the equation solution testing phase of this thesis, the algorithm of Reference [13] was selected. This algorithm was perceived to be well suited to the general test role for three reasons. Firstly, the number of equations which may be solved is theoretically limited only by the amount of out-of-core storage available to the computer. Secondly, the amount of core memory required for solution is uncoupled from the number of equations and may be independently selected when choosing the "block" size (the size of the square submatrices into which the complete systems is divided). No matter how large a percentage of the microcomputer memory is

taken up by the solution program, a sufficient (if not optimum) amount of core storage should remain for an acceptable block-size to be chosen. Lastly, the code is very simple to follow and requires the fewest number of instructions of the candidate algorithms. This makes a program easier to debug and more likely to fit into a small machine.

B. THE BLOCK SOLVER METHOD FOR OUT OF CORE SOLUTION OF SYSTEMS OF LINEAR EQUATIONS

The discussion which follows parallels that of Reference [13].

Consider Figure 1, which shows a positive definite, symmetric, sparse, banded matrix in an associated system of linear algebraic equations. The terms represented by "F" may be thought of as loads or generalized forces, such that "U" and "K" might then represent generalized displacements and equivalent stiffnesses, respectively. The general elements " F_N " and " U_N " are themselves vectors having, say, NS components and the general terms " K_{IJ} " are NS-by-NS square sub-matrices. The variable NS is defined as the blocksize, and will eventually determine the amount of core required to solve any arbitrarily large system.

Figure 2 illustrates the block half-bandwidth M (or MM or Mm) and shows that portion of the complete stiffness matrix which must be stored, for this algorithm, to effect a solution. Storage for fully N-by-M blocks of the stiffness matrix is reserved, even though this is more than is

absolutely required to hold one complete half-band. The extra blocks are used for storage of intermediate results of calculations during the solution.

The program requires that an NS-by-NS block of loads, each containing a single portion of the complete load vector, be stored following its associated row of stiffness blocks. In the present form of this algorithm only one "right-hand-side" is stored in each load block and most of the space in these blocks is unused. It would be a simple matter, once the solution procedure is understood, for the reader to modify the program to allow up to NS multiple right hand sides (and only slightly more difficult to allow a greater number).

It is recommended that all blocks (both stiffness and load) be stored in a single, large, one dimensional array, unless the language being used offers special advantages for other storage schemes.

The block solver algorithm itself is simply a form of Gaussian elimination which exploits the favorable characteristics of a system of finite element equations. The reader who is interested in discovering the solution scheme for him or her self is encouraged to complete the following exercise, by hand, with a 4-by-4 example:

1. Construct the first equation by matrix multiplication of block row one ($K_{11} - K_{1M}$) and the generalized displacements ($U_1 - U_N$).

$$\begin{bmatrix}
 K_{11} & K_{12} & K_{12} & \dots & \dots & K_{1M} & 0 & \dots & 0 \\
 K_{12}^I & K_{22} & K_{23} & K_{24} & \dots & \dots & K_{2,M+1} & 0 & \dots \\
 K_{13}^I & K_{23}^I & K_{33} & K_{34} & K_{35} & \dots & \dots & K_{3,M+2} & \dots \\
 . & . & . & . & . & . & . & . & . \\
 K_{1M}^I & K_{2M}^I & \dots & \dots & K_{M-1,M}^I & K_{MM} & K_{M,M+1} & \dots & K_{M,2M} \\
 . & . & . & . & . & . & . & . & . \\
 \dots & K_{1-M+1,1}^I & \dots & \dots & K_{1-1,1}^I & K_{11} & K_{1,1+1} & \dots & K_{1,1+M-1} \\
 . & . & . & . & . & . & . & . & . \\
 0 & \dots & \dots & 0 & K_{N-M+1,N}^I & \dots & \dots & K_{N-1,N}^I & K_{NN}
 \end{bmatrix}
 \begin{Bmatrix}
 U_1 \\
 U_2 \\
 U \\
 . \\
 U_M \\
 . \\
 U_1 \\
 . \\
 U_N
 \end{Bmatrix}
 =
 \begin{Bmatrix}
 F_1 \\
 F_2 \\
 F \\
 . \\
 F_M \\
 . \\
 F_1 \\
 . \\
 F_N
 \end{Bmatrix}$$

Figure 1. A Hypothetical System of Linear, Algebraic Equations Generated by the Finite Element Method

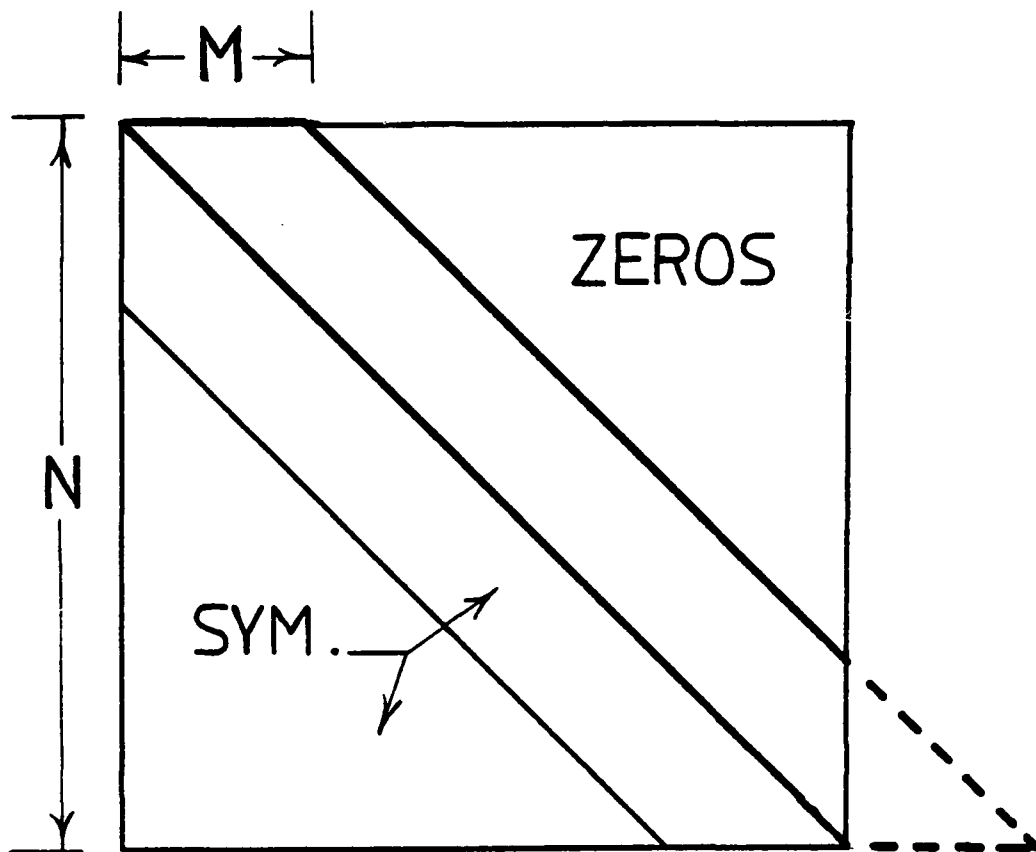


Figure 2. The Banded Character of the Equivalent Stiffness Matrix

2. Solve the first equation for U_1 using the inverse of the diagonal block of the current row, in this case K_{11}^{-1} . That is:

$$U_1 + K_{11}^{-1} (F_1 - K_{12}U_2 - K_{13}U_3 - \dots - K_{1M}U_M)$$

3. Construct the next equation by matrix multiplication of block row two and the generalized displacements.
4. Substitute the expression for U_1 , obtained from the first equation, into the second. Collect the terms which multiply each displacement block and which involve only force blocks.
5. Use the collected terms to reduce load and stiffness blocks as shown below:

$$F_2^* = F_2 - K_{12}^T K_{11}^{-1} F_1$$

$$K_{34}^* = K_{34} - K_{13}^T K_{11}^{-1} K_{14}$$

or, more generally:

$$F_M^* = F_M - K_{1M}^T K_{11}^{-1} F_1$$

$$K_{IJ}^* = K_{IJ} - K_{1I}^T K_{11}^{-1} K_{1J}$$

6. The expression for U_1 obtained in step 2 must be used to reduce all stiffness coefficients in block rows 2 to M and block columns 2 to M and all load blocks associated with those block rows.
7. Once the reduction in step 6 is complete, the second equation is solved for U_2 and a similar reduction accomplished on block rows and column 3 to M+1 and their associated load blocks.
8. After reduction is complete through the Nth block row, the Nth equation will be:

$$F_N^* = K_{NN}^* U_N$$

This equation is solved directly for U_N , after which back substitution is used to solve all previous equations in the usual manner.

Upon completion of subroutine SOLVE the original stiffness matrix has been destroyed and the displacements reside in the blocks which originally contained the load vector.

The algorithm is coded using five subroutines and one function subprogram (or statement function definition, depending on the language chosen). Subroutine SOLVE is the control subprogram which carries out the steps outlined in the description of the algorithm. Subroutine MULT performs matrix multiplication of two arrays which have been stored

in unidimensional form. Subroutine SYMINV ensures that each diagonal block is truly symmetric, attempts to detect singularity or near singularity by examining the diagonal terms within the diagonal block, calculates and prints a condition number and inverts the block. An appropriate warning message is printed and, if necessary, the program is halted whenever an error condition exists. The condition number used is the product of the maximum column sum within the diagonal block before and after inversion and may be used to estimate the solution accuracy [13]. Subroutines RDDISK and WRDISK are machine dependent subroutines which read a specific record from a random access disk file. The function subprogram used has various names depending on the version (NTRACK, FNTrk,...) but is simply used to find the record number in which a block from block row I and block column J is stored. Other subroutines required to generate test matrices and to retrieve answers and control programs to call all of the above are discussed in the next section.

1. Enhanced BASIC Coding on the HP-9845A

The block solver algorithm was coded for the HP-9845A using subroutines SOLVE, RDDISK, WRDISK, MULT, SYMINV and function DEFINITION FNTrk. Since the subroutines are not overlaid, all are required to be in memory at the same time. All transfers within the controlling subroutine (SOLVE) are made to labels rather than statement numbers, so that the

program may be RENumbered at the convenience of the user. In order to decrease the run time of the program REMarks were kept to a minimum, a BUFFER was used and the most frequently called subroutines were placed first in sequence. OVERLAP mode is declared upon entry into subroutine SOLVE to allow simultaneous I/O and computation and SERIAL mode is declared upon exit to avoid disabling error traps in the calling program.

The HP-9845A version of this algorithm is given in Appendix B, along with a test program to generate various size systems of suitable equations (subroutine rest), print the answers (subroutine Answer) and to mimic the FORTRAN EQUIVALENCE statement (subroutine Equiv) which has no analog in BASIC.

A sample problem and program output is provided in Appendix C.

2. Apple FORTRAN Coding on the Apple-II Plus

The block solver algorithm was coded for the Apple-II Plus using subroutines SOLVE, RDDISK, WRDISK, MULT, SYMINV and, within SOLVE, implicit function definition NTRK(I,J). The above subroutines are all compiled into one object/p-code file by imbedding the appropriate \$INCLUDE statements at the end of SOLVE. Dummy dimensioning (e.g. AK1(1)) is used in all subroutines and array sizes are determined in the calling program, preferably by some dynamic means using a single workspace.

In order to handle substantial size problems in the face of random access file size limitations, subroutines RDDISK and WRDISK are set up to handle as many as four units (7-10), each of which must have been pre-defined/OPENed in the main calling program. In calling RDDISK or WRDISK, NACTIV is the desired record number, C is the array to be read or written, NENTRY is the one-dimensional size of C and NRECFY is the number of records per random access file.

The Apple-II Plus version of this algorithm is given in Appendix D, along with a series of subroutines and a main program to OPEN the necessary files and calculate file parameters (subroutine FILES), generate various size systems of suitable equations (subroutine TEST), write them into appropriate files (subroutine DISKWR) and read (subroutine DISKRD) and print (subroutine ANSWER) the answers. The control program (program THESIS) is also included in Appendix D and is organized to use OVERLAYS to link all portions of the test program into a single executable CODE file and to manage the workspace. A system of integer pointers (e.g. NAK1, NAK2, ...) divide up a workspace of 3000 floating point variables according to the chosen block size, number of equations and half-bandwidth.

A sample problem and program output is provided in Appendix E.

3. Solution Times

The table below is a summary of all the test runs made on each machine. Where the name of a system is absent, that particular combination of parameters, for one reason or another, was not attempted (e.g. the blocksize of 2 was not tested on the Apple-II because the Disk Drive was already continuously busy with a block size of 4).

For comparison purposes, the solution times obtained on a TEKTRONIX 4081 Graphics System Mini-computer with hard disk drive are included in the table. For more information on the TEKTRONIX version of the block solver, the reader is referred to Reference [15].

Sample solutions of systems of 160 equations with true half-bandwidths of 64 appear in Appendices C and E.

Table 6: Solution Times for Standard Equation Solving Trials

Number Block Rows (NN)	Block Half- Bandwidth (MM)	Square Block Size (NS)	Record Length In Bytes	Computer System Used -----	Solution Time (hr:min:sec) -----
16	16	2	32	HP9845A	0:7:45.44
8	8	4	128	HP9845A	0:2:23.57
			64	Apple-II	0:7:45.13
4	4	8	512	HP9845A	0:3:34.93
			256	Apple-II	0:5:28.67
2	2	16	2048	HP9845A	0:1:53.10
			1024	Apple-II	0:4:51.89
1	1	32	8192	HP9845A	0:2:41.67
			4096	Apple-II	0:5:29.93
4	2	8	512	HP9845A	0:0:52.33
			256	Apple-II	0:2:50.04

Table 6 (contd)

Number Block Rows (NN)	Block Half- Bandwidth (MM)	Square Block Size (NS)	Record Length In Bytes	Computer System Used -----	Solution Time (hr:min:sec) -----
6	3	8	512	HP9845A	0:2:22.92
			256	Apple-II	0:7:55.01
				TEK4081	0:0:09
8	4	8	512	HP9845A	0:5:05.99
			256	Apple-II	0:16:20.74
				TEK4081	0:0:23
12	5	8	512	HP9845A	0:11:48.64
			256	Apple-II	0:37:03.50
				TEK4081	0:0:40
16	6	8	512	HP9845A	0:22:15.91
			256	Apple-II	1:08:37.68
				TEK4081	0:1:17
20	7	8	512	HP9845A	0:37:14.14
			256	Apple-II	1:51:31.04
				TEK4081	0:2:10
20	8	8	512	HP9845A	0:45:47.61
			256	Apple-II	2:13:35.89
				TEK4081	0:2:28

C. COMPARISON AND DISCUSSION OF RESULTS

Problem solution times for both the HP-9845A and Apple-II Plus greatly exceeded those of the TEKTRONIX 4081 for identical systems of equations. Note that the TEKTRONIX 4081 never needed 2 1/2 minutes for any problem attempted while both of the test systems used more than this on most square sets of 32 equations. In general the HP-9845A needed only one third the solution time required by the Apple-II Plus.

Although it was originally intended that the TEKTRONIX 4081 single precision solution should be the standard for accuracy (i.e., the "exact" answer), it was discovered that the number of significant digits routinely carried in

HP-9845A computations exceeded that of the TEKTRONIX. This more precise machine word resulted in the answers of the HP-9845A being more accurate than those of the TEKTRONIX 4081 double precision solution. Using the HP-9845A answers as the true solution, the Apple-II Plus was found to be accurate to three significant figures. The more than two hours of computation (including 20 matrix inversions) required of the Apple-II Plus for the largest problem was considered a sufficiently rigorous test of machine accuracy.

The first five runs shown in Table 6 were all square systems of 32 linear algebraic equations in 32 unknowns. The major difference in these problems was the record length, as determined by the square blocksize and floating point word size, although the problems with larger blocksizes were progressively more dense. This density difference was negligible for the algorithm chosen because the skyline within a given block is never examined nor used to reduce the number of arithmetic operations. It was expected that optimum record lengths would be those which matched the physical record size on the respective disk drive system and so result in the fastest Input/Output performance. In some cases, for the chosen algorithm, this particular size was not achievable (i.e., when the disk physical record length in bytes divided by the floating point word size in bytes was not a perfect square). The optimum record length is also affected by the relative

amounts of I/O and computation in a program and the ability of a machine to handle both simultaneously. The observed optimum block size for the HP-9845A and Apple-II Plus was 16 X 16. The remaining test combinations were run to gauge the amount of time to be expected for the solution of larger systems and to search for machine peculiarities which might place a practical limit on the number of equations.

III. IMPLEMENTATION OF REPRESENTATIVE CODES ON THE TEST SYSTEMS

Upon completion of initial testing of the equation solving capacity of the HP-9845A and Apple-II Plus a decision was made to continue the study by implementing a finite element code on these systems. The plan was to adapt an existing code to solve for forces and displacements in space trusses with static loading and to which other element and problem types could later be added. This adapted code would be re-programmed and modified to run on the test machines and be exercised on a number of problems of suitable difficulty. It was considered mandatory that the source program(s) use an out-of-core equation solver and desirable that some automatic node and element generation features be provided, with input data in a format familiar to users of general codes. Toward this end, a search was undertaken to find an appropriate source program.

A. PREVIOUS WORK ON THE HP-9845A

Reference [3] describes Mallory's success in modifying STAP [12] to produce SSAP-NPS for the HP-9845A with tape mass storage. SSAP-NPS solves 2-D and 3-D trusses using an in-core equation solver. Although some thought was given to the possibility of modifying it to solve out-of-core and to adding additional elements, time constraints finally

dictated that this idea be abandoned in favor of developing a code for the Apple-II Plus. STAP-NPS was, however, modified by changing the mass storage unit specifiers in the program to select the newer flexible disk drives rather than the older tape units. Test runs using Mallory's original problems were made with significant reductions in solution time.

B. APPLE-II PLUS IMPLEMENTATION OF STAP-NPS

The challenge of implementing a finite element code on the Apple-II Plus really involved overcoming the limitation on the number of subroutine/function calls which may be made by a program (see Appendix A). The random access file size limit (32768 bytes maximum length) was not reached in any of the test problems run in for the thesis (STAP-NPS will presently not allow the stiffness matrix to occupy multiple files). The slow speed and three significant figure accuracy observed in the Apple-II were already considered in the first phase of the study.

1. Software Sources

Many of the popular codes in use today are extensions of the pioneering work of Dr. Edward L. Wilson of the University of California at Berkeley. It was from such sources that STAP-NPS evolved.

The main program, exclusive of element dependent subroutines, was taken from the program STAMOD⁶ by Nor, while truss element subroutines were taken from Reference [12].

2. Program Development

The preliminary development of STAP-NPS for the Apple-II was done using an IBM 3033 mainframe computer and IBM FORTRAN at the W. R. Church Computer Center, Naval Postgraduate School, Monterey, California. STAMOD was loaded from an existing card deck while subroutines RUSS and TRUSS [12] were entered by hand. Missmatch problems in COMMON blocks and SUBROUTINE calls were resolved and the database structure was set up. The resulting program was then converted from double to single precision (the Apple-II has only single precision) and tested on several problems.

Up to this point STAP-NPS was one single program. The next step was to split the program up into separate segments, each of which had the maximum allowable number and depth of FUNCTION and SUBROUTINE calls and which would fit in the Apple-II's memory. Estimates of what would "fit" were based on previous experience and careful study of the number of variables needed in memory for each major program phase. It was finally decided to break the program into seven parts.

⁶An unpublished program used in supporting studies for "REALISATION ET ETUDE D'ELEMENTS DE COQUE DE MINDLIN," Sopha Nor, Doctoral Dissertation, Universite de Technologie de Compiègne, France, 29 June 1978.

3. STAP-NPS

The FORTRAN names of the seven PROGRAM segments are PROBLM, ELEMS, LOAD, BLOCKS, ASEMBL, SOLVE and STRES. Note, however, that these programs will identify themselves by a more complete title when interactively communicating with the user (e.g., ASSEMBLE vice ASEMBL for the fifth segment). Each segment has certain major functions which it is expected to accomplish and certain subroutines with which it is associated.

Program PROBLM determines the language in which the output is to be printed (both French and English are available), reads control parameters and nodal point information, automatically generates nodes as directed, reads and stores boundary conditions for global, nodal degrees of freedom and determines the total number of equations to be solved.

Program ELEMS calls the appropriate element subroutine (only a truss element is currently available), reads and stores connectivity information, automatically generates elements as directed and calculates the characteristics of the global stiffness matrix.

Program LOAD reads in loading information and calculates and stores load vectors.

Program BLOCK considers problem size and user recommended block size and determines the actual blocksize to be used. Direct access record length and actual block size are then used to develop an indexing scheme for locating any

coefficient in the global stiffness matrix within its random access file. The number of columns of the compact, global stiffness matrix and the first coupled blocks, per block, are calculated and stored.

Program ASEMBL calls the appropriate element subroutine and calculates and stores the compact form of the global stiffness matrix.

Program SOLVE has two separate modes of operation. The first time SOLVE is run LDL^T factorization [12] is performed on the stiffness matrix, the first loadcase vector is reduced and multiplied by the resulting factored form, back substitution is carried out and the answers (i.e., the nodal displacements) are stored for calculation of stresses. In subsequent calls successive loadcase vectors are retrieved and used to calculate their respective displacements.

Program STRES calls the element subroutine, prints the nodal displacements and calculates and prints the element stresses.

a. Major Variables

The major variables used by STAP-NPS are shown below:

NUMNP	Number of nodal points.
NUMEG	Number of element groups.
NUMMAT	Number of materials.
NUME	Number of elements.

NDOF	Global degrees of freedom possible per node.
NEQ	Number of equations.
NLOAD	Number of loads within a given loading case.
NBLOCK	Number of blocks into which the global stiffness matrix is divided for solution purposes.
ISTOTE	Desired number of coefficients per block.
ISTOH	Actual number of coefficients per block as calculated by the program based upon the remaining workspace and the problem size.
X(NUMNP)	X coordinate of each nodal point.
Y(NUMNP)	Y coordinate of each nodal point.
Z(NUMNP)	Z coordinate of each nodal point.
ID(NDOF*NUMNP)	Contains a one for each inactive degree of freedom and a zero for each active degree of freedom. Zeros are later changed to the equation number which will provide the solution for that D.O.F. and node and the ones are changed to zeros [12, 19].
E(NUMMAT)	Young's modulus for each material group used in the structure.
AREA(NUMMAT)	X-sectional area for each material group used in the structure.
XYZ(6 * NUME)	Each column contains the cartesian coordinates which apply to a single element. Rows 1-3 and 4-6 contain information on the "i" and "j" ends of the element, respectively.

MHT(NEQ)	Vector of column heights in the global stiffness matrix. This information allows a compacted (having fewer zeros) one-dimensional form of the global stiffness matrix to be stored and accessed. The skyline may be reconstructed from the MHT vector [12].
MAXA(NEQ + 1)	Stores the addresses of the diagonal elements of the compacted global stiffness matrix. MAXA(1) is always one and MAXA(NEQ + 1) is always the total number of elements in the compact stiffness matrix plus one.
LM(6 * NUME)	Each column of this array holds connectivity information for one element. Each row represents a local element degree of freedom and each entry in LM is a global equation number taken from the ID array.
MATP(NUME)	Contains the material type of each element. The entries in this vector become NUMMAT for retrieving the Young's modulus and x-sectional area.
R(NEQ)/V(NEQ)	A single load vector describing one loadcase (i.e., a "right-hand-side"). R is calculated from the individual global, nodal loads in FLOAD and the ID array.

FLOAD(NLOAD)	Vector of individual, concentrated forces applied to global nodes within one loadcase.
NOD(NLOAD)	Vector of global node numbers to which concentrated forces are applied within one loadcase.
IDIRN(NLOAD)	Vector of principal cartesian coordinate directions along which nodal forces are applied within one loadcase.
NCOLBV(NBLOCK)	Vector containing the number of columns stored within a given block of the compressed stiffness matrix.
ICOPL(NBLOCK)	Vector containing the number of the first block which is coupled to another particular block of the compressed stiffness matrix.
AA or A or B (ISTOH)	Various blocks of the compressed stiffness matrix during the assembly, factorization and back substitution phases.
D(NEQ)	Vector of nodal displacements in the global degrees of freedom (i.e., the answer to the problem).

b. Management of Variable Storage Space

In programming a microcomputer it is convenient to use one single, large array called a "workspace" for storing most variables which will be READ or calculated by the program. The size of the one large array may be adjusted to allow the maximum number of variables to be present in

memory along with the program instructions. Pointers are used to keep track of and locate sub-arrays within the workspace and are used to pass the locations in SUBROUTINE or function CALLs. Because the Apple-II does not use the same number of bytes for the storage and representation of integer numbers and floating point numbers, two separate workspaces (one integer and one real) must be used. Normal schemes of incrementing the pointers differently to locate intermingled floating point and integer sub-arrays cannot be used.

The integer workspace is the array IA which is dimensioned MTOTI and is contained in COMMON block IWORK. The real workspace is the array A which is dimensioned MTOTR and is contained in COMMON block RWORK. Integer and real pointers begin with NI and NR, respectively, and change their true position within the workspaces, during each major phase of the problem, as the variables they represent are shuffled about. When the workspaces are passed to subroutine RWCOMN the pointers NENDI and NENDR mark the highest numbered elements of IA and A which must be written into and, in the next segment, read from mass storage. The following two tables show the pointer allocations throughout the solution process:

Segment:		Table 7: Integer Workspace Pointer Allocation						
		PROBLEM	FLEMENTS	LOADS	BLOCKS	ASSEMBLE	SOLVE	STRESS
Integer Pointer								
NI1	ID	ID	ID	ID	MHT	MHT	MAXA	MAXA
NI2	not used	MHT	MHT	MHT	MAXA	MAXA	NCOLBV	NCOLBV
NI3	not used	MAXA	MAXA	MAXA	LM	NCOLBV	ICOPL	ICOPL
NI4	not used	LM	LM	LM	MATP	ICOPL	ID	ID
NI5	not used	MATP	MATP	MATP	NCOLBV	LM	LM	LM
NI6	not used	not used	not used	NOD	ICOPL	MATP	MATP	MATP
NI7	not used	not used	not used	IDIRN	not used	not used	not used	not used

Table 8: Real Number Workspace Pointer Allocation

Segment:	PROBLEM	ELEMENTS	LOADS	BLOCKS	ASSEMBLE	SOLVE	STRESS
Real Pointer							
NR1	X	X	E	E	AA	A	A
NP2	Y	Y	AREA	AREA	E	B	B
NR3	Z	Z	XYZ	XYZ	AREA	D	D
NR4	not used	E	R	R	XYZ	V	V
NR5	not used	AREA	FLCAD	not used	not used	E	E
NR6	not used	XYZ	not used	not used	not used	AREA	AREA
NR7	not used	not used	not used	not used	not used	not used	XYZ

The pointers are modified in several programs and subroutines in STAP-NPS. Each time the numerical value of the highest active pointer is increased a check must be made to ensure that no element of the workspace will be stored outside its dimensioned area. The magnitude of the topmost active pointer is compared to MTOTI or MTOTR, as appropriate, and if the required value is too large subroutine ERROR is called. Subroutine ERROR prints a diagnostic message showing the amount by which the offending pointer exceeds the memory available and the problem phase which cannot be accomplished. The user then has the option of attempting to set MTOTI and MTOTR closer to the machine limits, rearranging the mesh into smaller pieces (e.g., by using multiple element groups) or abandoning the Apple-II for a larger machine and program.

The first six segments of STAP-NPS all have entry and exit diagnostics which will display the contents of the integer and floating point workspaces. The printing of these diagnostics may be declined by the user. They were first included in the programs to assist in debugging and were allowed to remain so that users could more easily modify or add to the code. These diagnostics could also be of value to the beginning student of the finite element method.

c. The Database and Communication Between Program Segments

Communication between programs was accomplished by including a new subroutine (RWCOMN) in each segment. This subroutine writes the contents of the entire COMMON block (which is the same group of variables in each segment) and all other necessary integer and real variables into an unformatted, serial disk file. All segments, except the first, resume solving the problem after calling RWCOMN with an argument of "1", thereby receiving the necessary data from previous calculations and READs. All segments call RWCOMN with an argument of "2" as their final action before closing file ICOM and stopping. The old ICOM file from the previous segment is deleted just before the new one is written, well after any run time errors could affect its contents.

Program STAMOD was already organized around six FORTRAN I/O units which naturally evolved into the remaining database files for STAP-NPS. These database files are:

IIN

This sequential, formatted file contains the input data for the problem to be solved. IIN is an internal name only; the actual name of this file is entered interactively by the user. (If CONSOLE:\$ is entered then IIN becomes the keyboard.) It is created by the user with the Apple E(ditor before program PROBLM is run and is read by programs PROBLM, ELEMS and LOAD.

IOUT

This sequential, formatted file contains all printed output for the problem to be solved. IOUT is an internal name only; the actual name of this file is entered interactively by the user. (If a file other than PRINTER:\$ or CONSOLE:\$ is specified, the contents must be examined before the next segment is run or be lost.)

IDTAP

This sequential, unformatted file contains the ID array. It is created in program PROBLM and read in program SOLVE.

IELMNT

This sequential, unformatted file contains an indexing parameter (MIDEST), the element type (NPAR1) and NUME, NUMMAT, E, AREA, XYZ, LM, and MATP for each element group. It is created in program ELEMES and read in programs ASEMBL, SOLVE and STRESS.

ILOAD

This sequential, unformatted file contains R vectors from the various load cases. It is created in program LOAD and read in program SOLVE.

IRIG

This random access, unformatted file contains the condensed, and later factored, form of the global stiffness matrix. It is created in program ASEMBL and read in program SOLVE. The record length is user selectable by changing the variable LONG in program PROBLEM.

ICOM

This sequential, unformatted file contains the active portions of the real and integer workspaces and the contents of all other COMMON blocks. It is created or re-written in each program segment and all but the first read this file through subroutine RWCOMN.

4. Running STAP-NPS

In order to "X(ecute" the programs in STAP-NPS the following disks, at a minimum, are needed:

FORT1:

Contains APPLE FORTRAN (Pascal) Operating system. Also contains the F(iler and E(ditor for creating input data files for the problem to be solved.

DATA1: (or DATA3:)

Contains executable CODE files for the first five segments/programs in STAP-NPS. Also contains the input data TEXT files for the four problems used for original program testing.

DATA2: (or DATA4:)

Contains executable CODE files for the last two segments/programs in STAP-NPS.

TWO SCRATCH DISKS

Any two formatted disks having sufficient space for database files. These two disks must NOT be write protected. Normal program execution will not damage pre-existing files.

To actually run the programs:

- (1) Load volume 4 with FORT1:, volume 5 with DATA1:
and volumes 11 and 12 with scratch diskettes.
- (2) Turn on the monitor and other peripherals.
Energize the Apple-II Plus and observe initial
program loading of the FORTRAN Operating System.
- (3) Enter the F(iler and set the date. Enter the
E(ditor and create file IIN using the format
shown in the following subsection.
- (4) X(ecute programs #5:ONE.CODE through #5:FIVE.CODE.
These are simply the executable p-code files of
programs PROBLM through ASEMBL. Interact and
provide information as requested.
- (5) Remove DATA1: from volume 5 and replace it with
DATA2:
- (6) X(ecute programs #5:SIX.CODE and #5:SEVN.CODE
(executable p-code files of SOLVE and STRESS)
alternately until all loadcases have been solved
and the displacements and stresses printed.

a. Input Data Card Formats

Input data cards are actually lines of data in
database file IIN. The user is required to construct this
file using the E(ditor, prior to running STAP-NPS.

Language Option Card (20A4)

Note	Columns	Variable	Entry
(1)	1-4	Talk	FRAN for French ENGL for English

Notes:

- (1) This card must be included. Default language is English.

Heading Card (20A4)

Note	Columns	Variable	Entry
(1)	1-80	HED	Problem title

Notes:

- (1) This card must be included.

Master Control Card (1I5,6I1,1I4,3I5)

Note	Columns	Variable	Entry
	1-5	NUMNP	Total number of nodal points
(1)	6-11	IDOF	EQ. 0 free EQ. 1 fixed
	12-15	NUMEG	Number of element groups
	16-20	NLCASE	Number of load cases
	21-25	MODEX	EQ. 0 Data check EQ. 1 Solution
	26-30	ISTOTE	Desired number of coefficients per block

Notes:

(1) For two dimensional trusses enter "001111."

For three dimensional trusses enter "000111."

Default is "000000" which will use excessive
diskette storage and memory for the solution.

Nodal Point Definition Cards (A1,I4,A1,I4,5I5,3F10.0,I5)

Note	Columns	Variable	Entry
	1	IT	Blank for X,Y,Z, EQ. X Cylindrical
(1)	2-5	N	Node number
(2)	6	JPR	Print control see Note (2)
(3)	7-10	IDT(1)	EQ. 0 free EQ. 1 fixed (EQ.-1 fixed for automatic gener.)
(3)	11-35	IDT(2) - IDT(6)	EQ. 0 free EQ. 1 fixed (EQ.-1 fixed for automatic gener.)
	35-45	X	X coordinate of node N
(4)	46-55	Y	Y coordinate or radius - node N
(4)	56-65	z	Z coordinate or theta - node N

Note	Columns	Variable	Entry
(5)	66-70	KN	Node increment for automatic generation

Notes:

- (1) Need not be input in numerical order but eventually must read in nodes 1 through NUMNP. Last node read in must be node NUMNP.
- (2) Print control character only read from card for node number 1. Codes are:
 - Blank - no print suppression
 - EQ. A - suppress list of node coordinates
 - EQ. B - suppress list of equation numbers
 - EQ. C - suppress both of the above
- (3) These are local degrees of freedom and should be fixed where global conditions so require. When two consecutive cards are being used to automatically generate elements, all fixed degrees of freedom must be set to "-1" vice "1".
- (4) Cylindrical coordinates only if IT is non-blank.
- (5) Nodes generated in the sequence:

NODE1, NODE1+(1*KN1), NODE1+(2*KN1), . . . , NODE2

where NODE1 is N on the first, KN1 is KN on the first and NODE2 is N on the second of two consecutive Nodal Point Definition Cards. Default value of KN is "1".

Element Data Block Marker Card (1A4)

Note	Columns	Variable	Entry
(1)	1-4	BLOCK	ELEM

Notes:

- (1) This card must be included. It is the marker for Program ELEMS to begin reading element data from file IIN after unit rewind.

Material Group Specification Cards (15,2F10.0)

Note	Columns	Variable	Entry
	1-5	N	Material group
	6-15	E	Young's Modulus
	16-25	AREA	Truss element x-sectional area

Notes:

None.

Element Data Cards (5I5)

Note	Columns	Variable	Entry
(1)	1-5	M	Element number
	6-10	II	Node number at one end
	11-15	JJ	Node number at other end
	16-20	MTYP	Material type
(2)	21-25	KG	Increment for automatic element generation

Notes:

- (1) Put in ascending order beginning with number "1".
- (2) Missing elements are filled in by using the material type of the last card before the missed element and incrementing the element numbers by one and the node numbers by KG until the gap is closed.

Loading Data Block Marker Card (1A4)

Note	Columns	Variable	Entry
(1)	1-4	BLOCK	LOAD

Notes:

- (1) This card must be included. It is the marker for Program LOAD to begin reading loading case data from file IIN after unit rewind.

Load Case Control Cards (2I5)

Note	Columns	Variable	Entry
(1)	1-5	LL	Loading case number
	6-10	NLOAD	Number of loads within the load

Notes:

- (1) Enter in ascending order beginning with "1".

Concentrated Load Cards (2I5, F10.0)

Note	Columns	Variable	Entry
	1-5	NOD	Node to which load is applied
(1)	6-10	IDIRN	Principle direction
	11-20	FLOAD	Load magnitude

Notes:

(1) Positive directions only:

EQ. 1 - +X

EQ. 2 - +Y

EQ. 3 - +Z

For negative directions change the sign of FLOAD. Language Option Cards, Heading Cards, Master Control Cards and Data Block Marker Cards will appear only once in every file. Other cards will appear some number of times, dependent upon the particular problem being solved.

C. TESTING OF STAP-NPS

STAP-NPS was tested on four problems, the formatted input files of which appear in Appendix G. Problems were chosen for their varying degree of difficulty, the combination of features which they tested and the availability of a previous, reliable solution.

Truss number one was a simple three member problem, easily solvable by hand, which was used to debug the program. Truss number two had more nodes and elements and tested the multiple load case feature. Truss number three was a large crane with multiple materials and automatic node generation. Truss number four was a problem taken from Mallory's thesis [3] and tested the automatic element generation feature of the program and three dimensional operation. The cylindrical coordinate option and print suppression features have never been tested.

The English language program output from solving truss number four is given in Appendix H. The output of the first segment for the same problem with French as the chosen language has also been included.

IV. CONCLUSIONS

In concluding, two separate questions will be addressed. Firstly, what general techniques should be used when tailoring a finite element code to a microcomputer? Secondly, how well suited to finite element work were the two test systems and what limitations were encountered in each?

When using a microcomputer system, programs should be designed around a complete data base. Files should contain, in so far as possible, only one type of information and have a format general enough for a variety of purposes (e.g., nodal point information for use by both stress calculation and graphics mesh plotting subroutines). Single workspaces with dynamic dimensioning (i.e., pointers that change with the problem) are recommended for the ease with which available memory may be managed. Overlay schemes for subroutines should be used to ensure that a minimum amount of memory is taken up by program instructions. In choosing the extent of overlaying to be used, study is required to determine the optimum balance between I/O and computation and the amount of core needed for variable storage.

Never select microcomputer operating system software (regardless of the language in use) which has low limits on the number of user subroutines accessible to main programs. Subroutines or functions should be able to be individually

overlaid even though they may reside in large libraries of many such routines. Beware of eight bit microcomputers whose small word size leads to accuracy problems (when double precision software is not available) and limits mass storage file size (i.e., where the operating system chooses to keep track of total bytes per file).

The Hewlett-Packard System 45 Desktop Computer exhibited only three negative attributes during this study. The first of these was its slow speed (a problem which has no practical solution). The second was the lack of a FORTRAN compiler. The third was the relatively high cost of the HP-9845A compared to other micro- and even mini- computers. Although the System 45 is extremely accurate and capable, it is much in demand for graphics related work (for which it is perhaps best suited) and it is probably not cost effective to devote so expensive a machine to hours of slow and deliberate number crunching. Organizations who wished to use the HP-9845A for finite element calculations would, however, experience few difficulties.

The Apple-II Plus Personal Computer, with the operating system and hardware configuration previously discussed, is not a suitable tool for serious finite element work. The reader will recall that:

- (1) The system is too slow, taking over two hours to solve 160 equations having a half-bandwidth of 64.

- (2) There is a limit of seven compiler calls (\$USES statements) to external units for other subroutines or functions.
- (3) Random access files are limited to 32,768 bytes in total length.
- (4) The machine word is too small and double precision is not available. This causes a loss of accuracy in practical calculations.
- (5) Using more than one implicit function definition per program causes multiple subroutines with the name DUMMY to be generated and results in compile time errors.
- (6) Many machine features cannot be used with the FORTRAN language alone.

If the Apple-II must be employed it is recommended that another operating system and central processor chip be used.

The author looks forward in anticipation to the wedding of the finite element method and the microcomputers of the future and to the powerful vehicle of discovery which will then be widely available.

APPENDIX A

SEPARATE COMPILE OF APPLE FORTRAN PROGRAM SEGMENTS

Due to the small size of the Apple-II Plus memory, it is often necessary to compile larger programs in separate pieces and/or to overlay certain subroutines during execution of a large main program. This is made possible in Apple FORTRAN through the use of compiler directives [9].

Compiler directives are used to communicate information to the compiler via the FORTRAN TEXT file. These statements all begin with a dollar sign in column one and some have special requirements as to their location within a file (e.g. \$USES statements must be placed at the beginning of a TEXT file and may only be preceded by Comment lines). For details about the majority of compiler directives statements see Reference [9]. A brief commentary on some of the statements appears in the table below:

Table 9: Compiler Directives in Apple FORTRAN

<code>\$INCLUDE filename</code>	Tells the compiler when this statement is encountered to immediately compile the contents of the FORTRAN TEXT file filename.
---------------------------------	--

Table 9 (contd)

\$XREF

This statement produces a cross-reference listing of the compilation. Note that the extra information generated by this statement reduces the size of programs which may be compiled. If not absolutely required this directive should be avoided.

\$EXT [type] FUNCTION name #params

\$EXT SUBROUTINE name #params

Used to identify assembly language program calls and not used in this thesis.

The format of the \$USES control statement is:

\$USES unitname [IN filename] [OVERLAY]

where brackets enclose optional items and capitalized items, when appearing, must be exactly as shown.

The character string "unitname" is a Pascal term which actually represents a collection of P-code "procedures" or "functions" (FORTRAN subroutines or FORTRAN function subprograms previously compiled on the Apple) with their associated compiler directives. This collection is compiled as a single entity and remains together during any OVERLAY. The great disadvantage in this technique is that more code will be called into core than is actually needed whenever unused subroutines reside in the same unit as one which is desired. If one decides to simply put a single subroutine in each unit to circumvent this problem, there remains a limit on the maximum number of \$USES statements which are allowed by the compiler in any one program.

The character string "filename" includes all of the information necessary for the compiler and linker to find the file and usually includes the diskette name or volume number followed by a colon, the file name followed by a period and the extension CODE. If the filename is not included the compiler and linker will expect to find the unit in the file #4:SYSTEM.LIBRARY.

The character string OVERLAY tells the compiler and linker that the unit named is to be loaded into core only when called and is to remain in memory only while the procedure of interest is in use.

A maximum of seven \$USES statements may appear in any one program or subprogram being compile. Whenever more than this number appear in a file, compile time error number 205 is generated and the system usually "hangs" and must be re-booted. This is a real inconvenience when setting up a program in modular form and assigning all repetitive tasks to subroutine or in setting up a large overlay scheme. For example, if one uses only one level of depth in program development (e.g. the main program calls all subroutines and no subroutine calls any other) then the program may be broken into only seven parts, some of which may not be small enough to allow storage for the desired number of variables to reside in core. If graphics are required in any subroutine, one of the seven \$USES statements will probably have been used to link the TURTLEGRAPHICS unit from the

#4:SYSTEM.LIBRARY. For programs where subroutines call or overlay other subroutines the situation is much more complex and is best illustrated by the example in the following section.

Reference [9] discusses the use of the \$USES compiler directive when more than one level of depth is used in program development, but gives no actual examples. Since the solution of this problem is so critical to the success of implementing a large program on the Apple-II Plus, it was decided to examine a complex case of subroutine inter-connection.

The tables which follow contain actual files which were successfully compiled, linked and tested on the Apple-II. Although the files are real, they are simply presented as a hypothetical case which exercises the compiler and linker to the maximum extent and which illustrates to the reader how to structure a difficult program sequence. Nine subroutines are entered (I, C, III, S1, S2, S3, S4, S5, and IV) from a sequence of seven CODE files (ITOIV, S5, S4, S3, S2, S1, ATOD) on disk THESIS9: using all seven available \$USES statements. Note also that as long as no more \$USES statements are required, an even greater number of subroutine calls could be present (e.g., S5 could call I, II, and III which are in the same unit, and Pascal "segment," as IV).

Table 10: Contents of Demonstration File THESIS9:COMPILE.TEXT

```
$USES UI IN THESIS9:ITOIV.CODE OVERLAY
$USES US5 IN THESIS9:S5.CODE OVERLAY
$USES US4 IN THESIS9:S4.CODE OVERLAY
$USES US3 IN THESIS9:S3.CODE OVERLAY
$USES US2 IN THESIS9:S2.CODE OVERLAY
$USES US1 IN THESIS9:S1.CODE OVERLAY
$USES UA IN THESIS9:ATOD.CODE OVERLAY
PROGRAM CMPILE
CALL I
CALL C
CALL S1
STOP
END
```

Table 11: Contents of Demonstration File THESIS9:ITOIV.TEXT

```
SUBROUTINE I
WRITE(*,' (A) ') 'SUBROUTINE I ENTERED'
RETURN
END
SUBROUTINE II
WRITE(*,' (A) ') 'SUBROUTINE II ENTERED'
RETURN
END
SUBROUTINE III
WRITE(*,' (A) ') 'SUBROUTINE III ENTERED'
RETURN
END
SUBROUTINE IV
WRITE(*,' (A) ') 'SUBROUTINE IV ENTERED'
RETURN
END
```

Table 12: Contents of Demonstration File THESIS9:ATOD.TEXT

```
$USES UI IN THESIS9:ITOIIV.CODE OVERLAY
SUBROUTINE A
WRITE(*,' (A) ') 'SUBROUTINE A ENTERED'
WRITE(*,' (A) ') 'CALLING SUBROUTINE I'
CALL I
RETURN
END
SUBROUTINE B
WRITE(*,' (A) ') 'SUBROUTINE B ENTERED'
WRITE(*,' (A) ') 'CALLING SUBROUTINE II'
CALL II
RETURN
END
SUBROUTINE C
WRITE(*,' (A) ') 'SUBROUTINE C ENTERED'
WRITE(*,' (A) ') 'CALLING SUBROUTINE III'
CALL III
RETURN
END
SUBROUTINE D
WRITE(*,' (A) ') 'SUBROUTINE D ENTERED'
WRITE(*,' (A) ') 'CALLING SUBROUTINE IV'
CALL IV
RETURN
END
```

Table 13: Contents of Demonstration File THESIS9:S1.TEXT

```
$USES UI IN THESIS9:ITOIIV.CODE OVERLAY
$USES US5 IN THESIS9:S5.CODE OVERLAY
$USES US4 IN THESIS9:S4.CODE OVERLAY
$USES US3 IN THESIS9:S3.CODE OVERLAY
$USES US2 IN THESIS9:S2.CODE OVERLAY
SUBROUTINE S1
WRITE(*,' (A) ') 'SUBROUTINE S1 ENTERED'
WRITE(*,' (A) ') 'CALLING SUBROUTINE S2'
CALL S2
RETURN
END
```

Table 14: Contents of Demonstration File THESIS9:S2.TEXT

```
$USES UI IN THESIS9:ITOIV.CODE OVERLAY
$USES US5 IN THESIS9:S5.CODE OVERLAY
$USES US4 IN THESIS9:S4.CODE OVERLAY
$USES US3 IN THESIS9:S3.CODE OVERLAY
SUBROUTINE S2
WRITE(*,' (A)') 'SUBROUTINE S2 ENTERED'
WRITE(*,' (A)') 'CALLING SUBROUTINE S3'
CALL S3
RETURN
END
```

Table 15: Contents of Demonstration File THESIS9:S3.TEXT

```
$USES UI IN THESIS9:ITOIV.CODE OVERLAY
$USES US5 IN THESIS9:S5.CODE OVERLAY
$USES US4 IN THESIS9:S4.CODE OVERLAY
SUBROUTINE S3
WRITE(*,' (A)') 'SUBROUTINE S3 ENTERED'
WRITE(*,' (A)') 'CALLING SUBROUTINE S4'
CALL S4
RETURN
END
```

Table 16: Contents of Demonstration File THESIS9:S4.TEXT

```
$USES UI IN THESIS9:ITOIV.CODE OVERLAY
$USES US5 IN THESIS9:S5.CODE OVERLAY
SUBROUTINE S4
WRITE(*,' (A)') 'SUBROUTINE S4 ENTERED'
WRITE(*,' (A)') 'CALLING SUBROUTINE S5'
CALL S5
RETURN
END
```

The reader who is developing a large program for the Apple-II Plus is encouraged to try placing the "skeleton" of the anticipated program on the machine before proceeding with final coding. This will confirm that the control flow and overlay structure are possible, but will not prove that the final program will fit into core and leave room for the desired number of variables during execution.

Table 17: Contents of Demonstration File THESIS9:S5.TEXT

```
$USES UI IN THESIS9:IT0IV.CODE OVERLAY
SUBROUTINE S5
WRITE(*,'(A)') 'SUBROUTINE S5 ENTERED'
WRITE(*,'(A)') 'CALLING SUBROUTINE IV'
CALL IV
RETURN
END
```

If it becomes necessary, during program development or as a feature of the final code, to know the amount of free memory available for more instructions or variables, a Pascal program must be used. The reason for this is that the Apple-II Plus is really just a host for the "P-machine" or pseudo machine described in Reference [10] and this virtual machine uses Pascal accessible registers to keep track of memory allocation. Appendix 3 of the above reference contains a memory map which shows that the amount of free memory is defined to be the difference between "KP", which is the top of the program stack (this translates to the highest address

Chapter 15 of Reference [9] attempts to describe use of a Pascal FUNCTION unit by an Apple FORTRAN main program and gives an example Pascal program (complete with two minor, unintentional syntax errors).

In an attempt to make this requirement as painless as possible, the author has written and tested a Pascal program that will provide a FORTRAN function called MEMREM() which the reader may use to find out the amount of free memory remaining. The two tables below provide listings of the Pascal unit and a FORTRAN main program which will illustrate the use of the MEMREM() function. In order to use the function and test program the reader must:

1. Boot the system with the APPLE0: and APPLE1: diskettes in volumes #4: and #5.
2. Enter the E(ditor and I(nsert the Pascal unit as shown in the table below. Q(uit and U(Pdate as usual.
3. C(ompile the resulting TEXT file using the Pascal compiler. The resulting CODE file need not be L(inked.
4. Enter the F(iler and S(ave the TEXT and CODE files to the desired FORTRAN working diskette.
5. Create the FORTRAN program in the usual manner and C(ompile using the FORTRAN compiler after re-booting with FORT1: and FORT2: in volumes #4: and #5.
6. Enter the L(inker and link in the usual manner with the FORTRAN CODE file as host and SYSTEM.LIBRARY and the Pascal CODE files as library files.

Table 18: Contents of Pascal File #11:MEMREM.TEXT

```
(*SP*)
(*SS+,L CONSOLE: *)
UNIT MEMORY;
INTERFACE
  FUNCTION MEMREM: INTEGER;
  IMPLEMENTATION
    FUNCTION MEMREM;
    BEGIN
      MEMREM:=MEMAVAIL;
    END;
  BEGIN
    (* THIS FUNCTION RETURNS THE AMOUNT OF FREE MEMORY *)
  END.
```

Table 19: Apple FORTRAN Program Example Using the MEMREM ()
Function

```
SUSES MEMORY IN #11:MEMREM.CODE
C
  PROGRAM MEMTST
C
  IMPLICIT REAL(A-H,O-Z, INTEGER(I-N)
  INTEGER WORDS,REALS,BYTES
C
  WORDS = MEMREM ()
  BYTES = 2 * WORDS
  REALS = WORDS / 2
C
  WRITE(*,10) BYTES,WORDS,REALS
C
  STOP
C
10 FORMAT(//,' SPACE REMAINING FOR:',//,
1 4X,1I8,' BYTES OF A PROGRAM OR',//,
1 4X,1I8,' INTEGER VARIABLES OR',//,
1 4X,1I8,' REAL VARIABLES !!!')
C
  END
```

For comparison purposes, the test program given above resulted in a linked FORTRAN CODE file of 27 (512 byte) blocks of diskette storage (the bulk of which was consumed by the Run Time Unit code). When executed the program returned a value of 24512 bytes of program available out of an approximate theoretical maximum, prior to program loading, of 41,000 bytes. This is enough room for 12256 integer variables or 6128 floating point variables.

The reader should also note on the memory map in Reference [10] that both the program and the variables in the data heap appear to be able to write over the two pages of High-Resolution Graphics memory located between 8K and 24K in the Apple-II Plus RAM. The author has not investigated the possible ramifications of this storage scheme, but doubts the validity of the MEMREM() function if high resolution graphics are used in the same program with this function.

APPENDIX B

BLOCK SOLVER PROGRAM LISTING - HEWLETT PACKARD ENHANCED BASIC

SUBROUTINE SOLVE (HP9845A VERSION)

```

10 SUB SOLVE(Nn,Mm,Ns,File$)
20 ! *****
30 !
40 ! ORIGINAL CODE (IBM360/67 FORTRAN): GILLES CANTIN, DECEMBER 1969
50 ! REFERENCE: INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN
60 ! ENGINEERING, VOL. 3, 379-388(1971)
70 !
80 ! RE-CODED FOR HEWLETT-PACKARD SYSTEM 45 (9845A): APRIL 1981
90 !
100 ! PASSING PARAMETERS:
110 !   Mm   IS THE NUMBER OF COLUMNS OF BLOCKS
120 !   Nn   IS THE NUMBER OF ROWS OF BLOCKS
130 !   Ns   IS THE SIZE OF EACH BLOCK (Ns BY Ns ELEMENTS)
140 !   File$ IS THE FILE CONTAINING THE MATRIX TO BE SOLVED
150 !
160 ! IN PRESENT FORM THE SUBROUTINE IS INDEPENDENT OF THE TYPE OF MASS
170 ! STORAGE UTILIZED. DISK MASS STORAGE (HARD OR FLEXIBLE) IS RE-
180 ! COMMENDED. OVERLAP I/O MODE IS DECLARED UPON ENTRY TO MINIMIZE
190 ! WAITING TIME FOR READ/WRITE MASS STORAGE OPERATIONS. SERIAL MODE
200 ! IS DECLARED UPON EXIT TO AVOID DISABLING ERROR TRAPS IN THE CALL-
210 ! ING PROGRAM.

```

(1)

SUBROUTINE SOLVE (HP9845H VERSION)

```

220 ! ALL TRANSFERS WITHIN THE SUBROUTINE ARE MADE TO LABELS TO ALLOW
230 ! RE-NUMBERING FOR THE CONVENIENCE OF THE USER.
240 !
250 ! OTHER SUBROUTINES REQUIRED:
260 !   Rddisk, Wrdisk, Mult, SymInv
270 !
280 ! OTHER FUNCTION SUBROUTINES REQUIRED:
290 !   FNTrk
300 !
310 ! *****
320 ! ASSIGN #1 TO File$
330 ! BUFFER #1
340 ! OVERLAP
350 ! OPTION BASE 1
360 ! DIM AK1(Ns^2), AK2(Ns^2), AK3(Ns^2), Rb1(Ns), Rb2(Ns), Rb3(Ns)
370 ! N=0
380 ! Kmm=Mm
390 ! Sol100: N=N+1 ! THIS VARIABLE KEEPS TRACK OF THE CURRENT BLOCK ROW
400 ! Ntk=FNTrk(N,1,Mm)
410 ! Ntr=N*(Mm+1)
420 ! CALL Rddisk(#1,Ntk,AK2(*))
430 ! CALL SymInv(AK2(*),Ns,Rb1(*),Rb2(*),If1g)

```

(2)

SUBROUTINE SOLVE (HP9845A VERSION)

```

440 IF I19=1 THEN S01600
450 IF I19<>2 THEN S0110
460 PRINT "BLOCK ";N;" IS NEARLY SINGULAR"
470 BEEP
480 S0110: CALL Rddisk(N1,Ntr,Rb1(*))
490 CALL Mult(Ak2(*),Rb1(*),Rb2(*),Ns,Ns,1)
500 CALL Wrdisk(N1,Ntr,Rb2(*))
510 IF N=Nn THEN S01300 ! ARE WE DONE WITH THE LAST ROW OF BLOCKS ?
520 IF N=Nn-Mm+1 THEN S01120
530 Nmm=Nmm-1 ! FOR THIS ROW, THE FIRST COLUMN THAT WILL HAVE A ZERO BLOCK
540 S01120: FOR I=2 TO Kmm ! THIS LOOP REDUCES THE OTHER BLOCKS IN THIS ROW
550 Ntk=FNTR(N,I,Mm)
560 CALL Rddisk(N1,Ntk,Ak1(*))
570 CALL Mult(Ak2(*),Ak1(*),Ak3(*),Ns,Ns,Ns)
580 CALL Wrdisk(N1,Ntk,Ak3(*))
590 FOR I=1 TO Ns
600 I1=(I-1)*Ns
610 FOR J=1 TO Ns
620 I1=I1+J
630 I1=I1+I-1)*Ns
640 Ak3(I1)=Ak1(I1)
650 NEXT J

```

(3)

SUBROUTINE SOLVE (HP9845A VERSION)

```

600 NEXT I
610 Sol150: Ntk=FNTK(Nn,K,Mm)
620 CALL Wrdisk(01,Ntk,RK3(*))
630 Sol200: NEXT K
640 FOR I=2 TO Lmm: THIS LOOP REDUCES AFFECTED BLOCKS BELOW THE CURRENT ROW
650 I=N+L-1
660 IF I=N THEN Sol250
670 J=0
680 Ntk=FNTK(Nn,L,Mm)
690 CALL Rddisk(01,Ntk,RK2(*))
700 FOR K=L TO Kmm
710 J=J+1
720 Nn=Nn+N,K,Mm)
730 CALL Rddisk(01,Ntk,RK1(*))
740 CALL Wrdisk(RK2(*),RK1(*),RK3(*),Ns,Ns,Ns)
750 Ntk=FNTK(L,J,Mm)
760 CALL Rddisk(01,Ntk,RK1(*))
770 FOR I1=1 TO Ns/2
780 RK1(I1)=RK1(I1)-RK3(I1)
790 Sol210: NEXT I1
800 CALL Wrdisk(01,Ntk,RK1(*))
810 Sol250: NEXT K

```

(4)

SUBROUTINE SOLVE (MP98,5A,VER,ION)

```

800 CALL Mult(M12(*),Rb2(*),PE3(*),N3,NE,1)
890 Nr=1/(Mm+1)
900 CALL Rddisk(*1,Nr,Rb1(*))
910 FOR I1=1 TO N3
920 Rb1(I1)=Rb1(I1)-Rb3(I1)
930 Sol255: NEXT I1
940 CALL Wrdisk(*1,Nr,Rb1(*))
950 Sol260: NEXT L
960 GOTO Sol100 ! RETURN TO GET THE NEXT ROW OF BLOCKS
970 Sol300: N=N-1 ! THIS IS THE BEGINNING OF THE BACK SUBSTITUTION PHASE
980 IF N=0 THEN Sol500 ! ARE WE ALL FINISHED WITH THE SOLUTION ?
990 Nr=1/(Mm+1)
1000 CALL Rddisk(*1,Nr,Rb3(*))
1010 FOR K=2 TO Nmm
1020 L=N+K-1
1030 IF L=Nr THEN Sol400
1040 Nr=PHI(N,K,Mm)
1050 CALL Rddisk(*1,Nr,Rb1(*))
1060 Nr=1/(Mm+1)
1070 CALL Rddisk(*1,Nr,Rb1(*))
1080 CALL Mult(Rb1(*),Rb1(*),Rb2(*),N3,NE,1)
1090 FOR K1=1 TO N3

```

(5)

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SUBROUTINE SOLVE (NP9845A VERSION)

```

1100 P(3,1)=R(3(K1))-R(2,K1)
1110 S(1310)=NEXT K1
1120 S(1400)=NEXT K
1130 CALL W(1,K1,H1,R(3(K1)))
1140 K(1)=K(1)+1
1150 IF K(1)=M THEN S(1300)
1160 K(1)=M
1170 GOTO S(1300)
1180 S(1500)=SERIAL
1190 SUBEXIT
1200 S(1600)=PRINT "BLOCK ";N;" IS SINGULAR"
1210 S(1700)=BEEP
1220 DISP "ABNORMAL TERMINATION"
1230 STOP
1240 SUBEND

```

(6)

SUBROUTINE SIMINV (HF9845A, VERSION)

```

6000 SUB SIMINV(A(*),H,B(*),C(*),I,Ig)
6010 OPTION BASE 1
6020 I1Ig=0
6030 Mtrace=0
6040 FOR I=1 TO H
6050 Iad=(I-1)*N+1
6060 Mtrace=Mtrace+ABS(A(Iad))
6070 Sym005: NEXT I
6080 hpzro=Mtrace*1.0E-9
6090 Lp=N
6100 FOR I=2 TO Lp
6110 FOR J=1 TO Lp
6120 Icol=J+Lp*(I-2)
6130 Irow=I+(J-1)*Lp-1
6140 H A(Icol)=A(Irow) THEN Sym010
6150 H Icol)=.5*(H(Icol)+A(Irow))
6160 H Irow)=A(Icol)
6170 Sym010: NEXT J
6180 NEXT I
6190 FOR I=1 TO H
6200 B(I)=0
6210 I1=I-1)*N

```

(1)

SUBROUTINE SYMINV (HP9845A VERSION)

```

6220 FOR J=1 TO N
6230 JJ=1+J
6240 B(I)=B(I)+ABS(A(I,J))
6250 Sym020: NEXT J
6260 NEXT I
6270 Ann=0
6280 FOR I=1 TO N
6290 Ann=MAX(Ann,B(I))
6300 Sym030: NEXT I
6310 FOR I=1 TO N
6320 Hr=1-I*N
6330 FOR J=1 TO N
6340 V=Hr+J
6350 L=1+Hr+J
6360 Sym100: NEXT J
6370 D=B(I)
6380 IF D=0 THEN Sym100
6390 IF ABS(D)<HPZ00 THEN L=19=2
6400 FOR I=1 TO N
6410 CCJ=-1+CCJ+D
6420 Sym110: NEXT J
6430 L=1

```

(2)

SUBROUTINE STIMINV (HP,BSH,REPS,IND)

```

6440 FOR J=1 TO N
6450 M=L
6460 FOR I=J TO N
6470 RCL=RL+BJ*CKO
6480 SUM115: RCM=RL
6490 M=MH
6500 L=L+1
6510 SUM120: NEXT I
6520 L=L+J
6530 SUM130: NEXT J
6540 C1D=-1
6550 M=L
6560 M=L
6570 FOR I=1 TO H
6580 C1D=C1D
6590 RCM=C1D
6600 M=MH
6610 NEXT I
6620 SUM140: NEXT I
6630 M=MH
6640 FOR I=1 TO H
6650 C1D=-1+RCL

```

(3)

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SUBROUTINE SUMINV HP9845H VERSION

```

6650 SUM150: NEXT J
6660 FOR I=1 TO N
6670 B(I)=0
6680 I=(I-1)*N
6690 FOR J=1 TO N
6700 J=I+J
6710 B(I)=B(I)+ABS(A(I,J))
6720 NEXT J
6730 SUM160: NEXT I
6740 A=0
6750 FOR I=1 TO N
6760 A=A+B(I)*SUM150
6770 SUM170: NEXT I
6780 C=SUM170
6790 PRINT "CONDITION NUMBER ";C
6800 SUBEXIT
6810 I=19=1
6820 SUBEND

```

(4)

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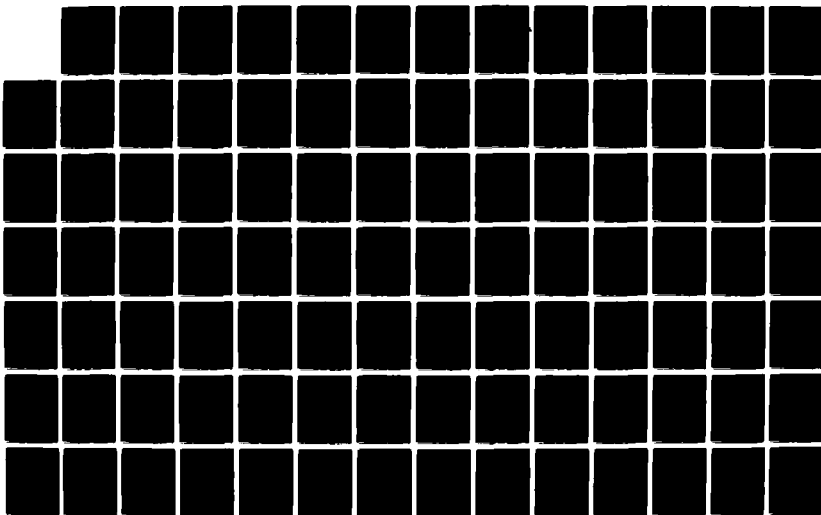
AN INVESTIGATION OF THE FEASIBILITY OF IMPLEMENTING
SUBSTANTIAL FINITE ELEMENT CODES ON POPULAR
MICROCOMPUTERS(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA
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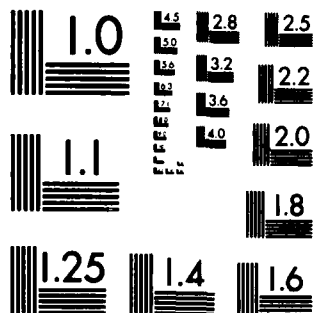
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M-2



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUBROUTINE MUL1 (HPS845H VERSION)

```

5000 SUB Mult(RC*), B(*), C(*), Hra, Hrb, Hrc, Hrd
5010 FOR I=1 TO Hra
5020 FOR J=1 TO Hrb
5030 Ic=I+(J-1)*Hra
5040 Temp=0
5050 FOR K=1 TO Hrc
5060 Ia=I+(K-1)*Hra
5070 Ib=I+(J-1)*Hra
5080 Temp=Temp+R(Ia)*B(Ib)
5090 Sum100: NEXT K
5100 C(Ic)=Temp
5110 NEXT J
5120 Sum110: NEXT I
5130 GOTO 5110

```

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 permit fully legible reproduction

SUBROUTINE R001SK (HF9845A VERSION)

3000 SUB R001SK(M1,Recno,RI(*))
3001 / THIS SUBROUTINE READS RECORD NUMBER Recno FROM FILE #1 INTO MATRIX
3002 / RI(*).
3010 OPTION BASE 1
3020 READ #1,Recno;RI(*)
3030 SUBEND

(1)

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permit fully legible reproduction

SUBROUTINE URD13 (HF0845A VERSION2)

4000 SUB URD13(K, #1, Recno, A1(*))
4001 ! THIS SUBROUTINE WRITES MATRIX A1(*) INTO RECORD NUMBER Recno IN FILE #1.
4010 OPTION BASE 1
4020 PRINT #1, Recno; A1(*)
4030 SUBEND

SUBROUTINE FNTRK (HF9045A VERSION)

```
2000 DEF FNTRK(I,J,Mm)
2001 ! THIS FUNCTION RETURNS THE RECORD NUMBER WHERE BLOCK(I,J) IS STORED.
2002 ! Mm IS THE SAME PARAMETER AS IN THE SOLVE ROUTINE.
2010 Trk=(I-1)*(Mm+2)+J-1+1
2020 RETURN Trk
2030 FNEHD
```

(1)

PROGRAM TEST (HP9845A VERSION)

```

10 INPUT "ENTER THE NUMBER OF ROWS OF BLOCKS:",Nn
20 INPUT "ENTER THE BLOCK HALF-BANDWIDTH:",Mm
30 INPUT "ENTER THE SUBMATRIX BLOCKSIZE:",Ns
40 Files="STIFF:F8,1"
50 CALL Test(Nn,Mm,Ns)
60 CALL Solve(Nn,Mm,Ns,Files)
70 CALL Answer(Nn,Mm,Ns,Files)
80 END
90 SUB Test(Nn,Mm,Ns)
100 OPTION BASE 1
110 DIM A(Ns,Ns),A1(Ns^2),B(Ns)
120 OVERFLOW
130 NumbRows=Nn*(Mm+1)
140 IF NumbRows<1 OR (NumbRows>32767) THEN A
150 Bksize=Ns^2
160 IF Bksize>32767 THEN A
170 Bksize=Bksize*8
180 IF Bksize>32767 THEN A
190 Phnrec=Bksize*256*NumbRows
200 IF Phnrec>1991 THEN A
210 GOTO Test001
220 A: DISP "IMPROPER PARAMETERS PASSED TO TEST PROGRAM"

```

(1)

PROGRAM TEST (HP9845A VERSION)

```

230 GOTO Abort
240 Test01: PRINT LIN(1)
250 PRINT "BLOCK SOLVER TEST RUN DATA:"
260 PRINT LIN(1)
270 PRINT " SUBMATRIX BLOCK SIZE (Ns): " ; Ns
280 PRINT " NUMBER OF ROWS OF BLOCKS (Nn): " ; Nn
290 PRINT " BLOCK HALF BANDWIDTH (Mm): " ; Mm
291 Numeqn=Nn*Ns
300 PRINT " NUMBER OF EQUATIONS: " ; Numeqn
301 Truehb=Mm*Ns
310 PRINT " TRUE HALF-BANDWIDTH: " ; Truehb
320 PRINT " TOTAL NUMBER OF BLOCKS: " ; Numblks
330 PRINT " BLOCKSIZE/RECORD LENGTH(Bytes): " ; Bytrec
350 PRINT LIN(1)
360 CREATE "STIFF:F8,1", Numblks, Bytrec
370 ASSIGN #1 TO "STIFF:F8,1"
380 MAT A=ZER
390 FOR I=1 TO Ns
400   FV=Ns+1
410   FOR J=1 TO Ns
420     IF J>Nn THEN Test200
430     FV=FV-1

```

(2)

PROGRAM TEST (HP9845A VERSION)

```

440 A(I,J)=FV
450 NEXT J
460 Test200: NEXT I
470 FOR I=1 TO Ns
480 FOR J=1 TO Ns
490 Test250: A(J,I)=A(I,J)
500 NEXT J
510 NEXT I
520 CALL Equiv(A1(*),A(*),Ns)
530 PRINT "THIS IS THE MATRIX THAT WAS PUT IN THE DIAGONAL BLOCKS:"
540 MAT PRINT A1
550 PRINT "DIAGONAL BLOCK/RECORD/TRACK NUMBERS GENERATED AND WRITTEN:"
560 FOR I=1 TO Nn
570 Recno=FNTK(I,1,Mm)
580 PRINT Recno;
590 PRINT #1,Recno;A1(*)
600 NEXT I
610 PRINT LIN(1)
620 MAT A=IDN
630 MAT A=A*(2)
640 CALL Equiv(A1(*),A(*),Ns)
650 PRINT "THIS IS THE MATRIX THAT WAS PUT IN THE OFF-DIAGONAL BLOCKS:"

```

(3)

PROGRAM TEST (HP9845A VERSION)

```
660 MAT PRINT A1
670 PRINT "OFF-DIAGONAL BLOCK/RECORD/TRACK NUMBERS GENERATED AND WRITTEN:"
680 FOR I=1 TO Nn
690   FOR J=2 TO Mm
700     Recno=FNTTrk(I,J,Mm)
710     PRINT Recno;
720     PRINT #1,Recno;A1(*)
730   NEXT J
740 NEXT I
750 PRINT LIN(1)
760 FOR I=1 TO Ns
770   B(I)=10.0
780 NEXT I
790 PRINT LIN(2)
800 PRINT "THIS IS THE MATRIX THAT WAS PUT IN THE R.H.S. BLOCKS:"
810 MAT PRINT B
820 PRINT "R. H. S. BLOCK/RECORD/TRACK NUMBERS GENERATED AND WRITTEN:"
830 FOR I=1 TO Nn
840   Recno=1+(Mm+1)
850   PRINT Recno;
860   PRINT #1,Recno;B(*)
870 NEXT I
```

(4)

PROGRAM TEST (HP9845A VERSION)

```
880 PRINT LIN(1)
890 SERIAL
900 SUBEXIT
910 SUBEND
920 SUB EQUIV(A1(*),A(*),Ns)
930 OPTION BASE 1
940 FOR I=0 TO Ns-1
950 FOR J=1 TO Ns
960 A1(I+Ns+J)=A(I+1,J)
970 NEXT J
980 NEXT I
990 PRINT LIN(2)
1000 SUBEND
```

(5)

SUBROUTINE ANSWER (HP9845A VERSION)

```
3420 SUB ANSWER(Nn,Mm,Ns,File$)
3430 OPTION BASE 1
3440 DIM B(Ns)
3450 ASSIGN #1 TO File$
3460 PRINT LIN(2),"ANSWERS:",LIN(2)
3470 FOR I=1 TO Nn
3480   Recno=I*(Mm+1)
3490   PRINT "FROM BLOCK ---";Recno
3500   READ #1,Recno;B(*)
3510   MAT PRINT B
3520 NEXT I
3530 PRINT LIN(2)
3540 SUBEND
```

(1)

APPENDIX C

SAMPLE EQUATION SOLUTION - HEWLETT PACKARD SYSTEM 45

BLOCK SOLVER TEST RUN DATA:

SUBMATRIX BLOCK SIZE (Ns): 8
 NUMBER OF ROWS OF BLOCKS (Nr): 20
 BLOCK HALF BANDWIDTH (Mm): 8
 NUMBER OF EQUATIONS: 160
 TRUE HALF-BANDWIDTH: 64
 TOTAL NUMBER OF BLOCKS: 180
 BLOCKSIZE/RECORD LENGTH(Bytes): 512

THIS IS THE MATRIX THAT WAS PUT IN THE DIAGONAL BLOCKS:

8	4	7	5	6	6	5	7	4	8	3	7	2	6	1	5
7	3	8	4	7	5	6	6	5	7	4	8	3	7	2	6
6	2	7	3	8	4	7	5	6	6	5	7	4	8	3	7
5	1	6	2	7	3	8	4	7	5	6	6	5	7	4	8

[illegible][illegible]

2	3	4	5	6	7	8	11	12	13	14	15	16	17	20	21	22	23	24	25	26	29
2	3	4	5	6	7	8	11	12	13	14	15	16	17	20	21	22	23	24	25	26	29

30	31	32	33	34	35	38	39	40	41	42	43	44	47	48	49	50	51	52	53
56	57	58	59	60	61	62	65	66	67	68	69	70	71	74	75	76	77	78	79
80	83	84	85	86	87	88	89	92	93	94	95	96	97	98	101	102	103	104	
105	106	107	110	111	112	113	114	115	116	119	120	121	122	123	124	125	126	127	
128	129	130	131	132	133	134	137	138	139	140	141	142	143	144	145	146	147	148	
149	150	151	152	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	
170	173	174	175	176	177	178	179												

THIS IS THE MATRIX THAT WAS PUT IN THE R.H.S. BLOCKS:

10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

R. H. S. BLOCK/RECORD/TRACK NUMBERS GENERATED AND WRITTEN:

9	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180
---	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----

CONDITION NUMBER 99.0000000005

CONDITION NUMBER 71.2308192552

CONDITION NUMBER 102.0000043489

CONDITION NUMBER 116.441895794

CONDITION NUMBER 124.736507109

CONDITION NUMBER 130.109221700

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CONDITION NUMBER	133.854262011
CONDITION NUMBER	136.601183783
CONDITION NUMBER	60.0419924713
CONDITION NUMBER	125.85385339
CONDITION NUMBER	2056.02559205
CONDITION NUMBER	235.96754888
CONDITION NUMBER	153.006058614
CONDITION NUMBER	487.7259791
CONDITION NUMBER	342.170017404
CONDITION NUMBER	2913.13227398
CONDITION NUMBER	84.1624662538
CONDITION NUMBER	57.772249913
CONDITION NUMBER	219.581763707
CONDITION NUMBER	68.6303115896

ANSWERS:

FROM BIC 11-19

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FROM BLOCK ---> 18
 .280022191395
 .117651307274

.19350694386
 .153445295692

.153445295692
 .19350694386

FROM BLOCK ---> 18
 .31587181691
 .117651307274

.166446329455
 .110973701786

.110973698455
 .166446325409

FROM BLOCK ---> 27
 .329856035171
 .105322491762

.166313387116
 .107538888521

.107538893846
 .166313388078

FROM BLOCK ---> 36
 .31361024021
 .097260855797

.166180447479
 .104104087559

.104104084141
 .166180444432

FROM BLOCK ---> 45
 .329856035171
 .105322491762

.166313387116
 .107538888521

.107538893846
 .166313388078

FROM BLOCK ---> 54
 .31361024021
 .097260855797

.166180447479
 .104104087559

.104104084141
 .166180444432

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 permit fully legible reproduction

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FROM BLOCK ---> 63				
.21442933269	.04540350611	.007888751655	.296350321656	
.296350331329	.007888751346	.045403502002	.214429333391	
FROM BLOCK ---> 72				
.094447891292	.280121342437	.203995770922	-.030722064013	
-.030722067952	.203995767444	.280121352559	.094447886406	
FROM BLOCK ---> 81				
.119623621003	.09951278322	.134840584298	.177312186516	
.177312182669	.134840589902	.099512777403	.119623623904	
FROM BLOCK ---> 90				
.108387440821	.13589965901	.144094233379	.147529035762	
.147529042792	.144094227347	.135899662854	.108387439733	
FROM BLOCK ---> 99				
.108387439934	.135899660666	.144094230102	.147529041325	
.147529035155	.144094235686	.135899657512	.10838744075	
FROM BLOCK ---> 103				

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.119520000000
 .177312182088
 .134640564029
 .09351000762
 .00001278276
 .14400580406

FROM BLOCK 111
 .09444788200
 .00000059911
 .28012134421
 .203995778527
 .203995774968
 .280121336624
 -.030722061945
 .094447882805

FROM BLOCK 126
 .21442934243
 .096350321684
 .045403509806
 .007888746932
 .007888750438
 .045403509663
 .296350316886
 .21442934212

FROM BLOCK 135
 .046350300424
 .10024301441
 .203995767839
 .296350320658
 .296350322988
 .20399577742
 .100243009535
 -.046351050465

FROM BLOCK 144
 .00268407582
 .00399500119
 .1041190044
 .001700131
 .06163248798
 .1041190189
 .093999368144
 .37968986963

FROM BLOCK 153
 .313840252857
 .097260861434
 .104104086696
 .104104048073
 .097260858124
 .313840252944

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FROM BLOCK 162
 .32985603472
 .105322485872
 .166313388561
 .107538894454
 .107538891279
 .166313384303
 .105322491352
 .329856037705

FROM BLOCK 171
 .345871817107
 .113384121689
 .166446327557
 .110973696971
 .110973699935
 .166446330451
 .113384118974
 .345871816124

FROM BLOCK 180
 .280022201234
 .116651297849
 .198506951025
 .153445299452
 .15344529444
 .198506948662
 .11665129544
 .280022200

APPENDIX D

BLOCK SOLVER PROGRAM LISTING - APPLE FORTRAN

PAGE: 1

SUBROUTINE SOLVE (APPLE-II VERSION)

SUBROUTINE SOLVE(NN,MM,NS,AK1,AK2,AK3,RB1,RB2,RB3,NRECFY)

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

CODE BY: GILLES CANTIN, DECEMBER 1969
FOR: THE IBM 360/67

MODIFIED BY: D. J. MULHOLLAND, LT, USN, MARCH 1982
FOR: APPLE II+ STANDARD FORTRAN CONFIGURATION

NN IS THE NUMBER OF BLOCKS PER COLUMN
MM IS THE NUMBER OF BLOCKS PER ROW
NS IS THE SIZE OF ONE BLOCK

NRECFY IS THE NUMBER OF BLOCKS OF THE CHOSEN RECORD SIZE
THAT ARE CONTAINED IN ANY SINGLE FILE.
THIS IS CALCULATED FROM AN APPLE LIMIT THAT NO
FILE MAY CONTAIN MORE THAN 32768 BYTES.

OTHER SUBROUTINE REQUIRED:

MULT, SYMINV, RDDISK, WRDISK

NOTES: SUBROUTINES WRDISK AND RDDISK ARE MACHINE DEPENDENT
AS ARE LINES 2555 AND 2565 OF SOLVE.

C*****

C

DIMENSION AK1(1), AK2(1), AK3(1), RB1(1), RB2(1),
1RB3(1)

C

NTRK(I, J) = (I-1)*(MM+2) + J-I+1

C

LRECS = (NS**2)*4
NCOUNT = NS*NS
N=0

KMM=MM

100 N=N+1

C

REDUCE BLOCK ROW "N"

C

1. -REDUCE R.H.S.

C

NTK=NTRK(N, 1)

NTR=N*(MM+1)

C

CALL RDDISK(NTK, AK2, NCOUNT, NRECFY)

CALL SYMINV(AK2, NS, RB1, RB2, IFLG)

C

IF(IFLG.EQ.1) GO TO 600

IF(IFLG.EQ.2) WRITE(6, 2000) N

C

CALL RDDISK(NTR, RB1, NS, NRECFY)

CALL MULT(AK2, RB1, RB2, NS, NS, 1)

SUBROUTINE SOLVE (APPLE-II VERSION)

```

C
C CALL WRDISK(NTR, RB2, NS, NRECFY)
C
C 2.- CHECK FOR LAST ROW OF BLOCKS
C IF(N.EQ.NN) GO TO 300
C
C 3.- REDUCE BLOCKS IN ROW "N"
C IF(N.GT. (NN-MM+1)) KMM=KMM-1
C
C DO 200 K=2, KMM
C NTK=NTRK(N, K)
C
C CALL RDDISK(NTK, AK1, NCOUNT, NRECFY)
C CALL MULT(AK2, AK1, AK3, NS, NS, NS)
C CALL WRDISK(NTK, AK3, NCOUNT, NRECFY)
C
C DO 150 I=1, NS
C II=(I-1)*NS
C
C DO 150 J=1, NS
C IL=II+J
C IR=I+(J-1)*NS
C
C 150 AK3(IL)=AK1(IR)

```

SUBROUTINE SOLVE (APPLE-II VERSION)

```

C
C      NTK=NTRK(NN,K)
C
C      CALL WRDISK(NTK,AK3,NCOUNT,NRECFY)
C
C      200 CONTINUE
C
C      4.- REDUCE REMAINING ROWS OF BLOCKS
C
C      DO 260 L=2,KMM
C
C          I=N+L-1
C          IF(I.GT.NN) GO TO 260
C          J=0
C
C          NTK=NTRK(NN,L)
C
C          CALL RDDISK (NTK,AK2,NCOUNT,NRECFY)
C
C          DO 250 K=L,KMM
C
C              J=J+1
C
C          NTK=NTRK(N,K)
C
C          CALL RDDISK(NTK,AK1,NCOUNT,NRECFY)
C          CALL MULT(AK2,AK1,AK3,NS,NS,NS)
C

```

SUBROUTINE SOLVE (APPLE-II VERSION)

```

      NTK=NTRK(I, J)
      C
      CALL RDDISK(NTK, AK1, NCOUNT, NRECFY)
      C
      DO 210 I1=1, NCOUNT
      210 AK1(I1)=AK1(I1)-AK3(I1)
      C
      CALL WRDISK(NTK, AK1, NCOUNT, NRECFY)
      C
      250 CONTINUE
      C
      CALL MULT(AK2, RB2, RB3, NS, NS, 1)
      C
      NTR=I*(MM+1)
      C
      CALL RDDISK(NTR, RB1, NS, NRECFY)
      C
      DO 255 I1=1, NS
      255 RB1(I1)=RB1(I1)-RB3(I1)
      C
      CALL WRDISK(NTR, RB1, NS, NRECFY)
      C
      260 CONTINUE
      C
      GO TO 100
      C
      BACK SUBSTITUTION
      C
      C
  
```

SUBROUTINE SOLVE (APPLE-II VERSION)

```

300 N=N-1
C
C      1.- CHECK FOR FIRST ROW OF BLOCKS
C
IF(N.EQ.0) GO TO 500
C
C      2.- CALCULATE BLOCKS OF UNKNOWNNS
C
NT1=N*(MM+1)
C
CALL RDDISK(NT1,RB3,NS,NRECFY)
C
DO 400 K=2,KMM
C
L=N+K-1
IF(L.GT.NN) GO TO 400
C
NTK=NTRK(N,K)
C
CALL RDDISK(NTK,AK1,NCOUNT,NRECFY)
C
NTR=L*(MM+1)
C
CALL RDDISK(NTR,RB1,NS,NRECFY)
CALL MULT(AK1,RB1,RB2,NS,NS,1)
C
DO 310 K1=1,NS
310 RB3(K1)=RB3(K1)-RB2(K1)

```

120

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SUBROUTINE SOLVE (APPLE-II VERSION)

\$INCLUDE SCRATCH:WRDISK.TEXT
\$INCLUDE SCRATCH:RDDISK.TEXT

```

SUBROUTINE SYMINV (APPLE-II VERSION)
C
SUBROUTINE SYMINV(A,N,B,C,IFLG)
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
DIMENSION A(1),B(1),C(1)
C
IFLG=0
ZRO=0.0E0
TRACE=ZRO
C
DO 5 I=1,N
IAD=(I-1)*N+I
5 TRACE=TRACE+ABS(A(IAD))
C
APZRO=TRACE*1.0E-6
LP=N
C
DO 10 I=2,LP
DO 10 J=1,LP
C
ICOL=J+LP*(I-2)
IROW=I+(J-1)*LP-1
IF(A(ICOL).EQ.A(IROW)) GO TO 10
A(ICOL)=0.5E0*(A(ICOL)+A(IROW))
A(IROW)=A(ICOL)
C
10 CONTINUE
C

```

SUBROUTINE SYMINV (APPLE-II VERSION)

```

C      DO 20 I=1,N
C      B(I)=ZRO
C      II=(I-1)*N
C      DO 20 J=1,N
C      JJ=II+J
C      20 B(I)=B(I)+ABS(A(JJ))
C      ANR=ZRO
C      DO 30 I=1,N
C      30 ANR=AMAX1(ANR,B(I))
C      DO 140 I=1,N
C      NR=(I-1)*N
C      DO 100 J=1,N
C      K=NR+J
C      100 B(J)=A(K)
C      D=B(I)
C      IF(D.EQ.ZRO) GO TO 180
C      IF(ABS(D).LT.APZRO) IFLG=2

```


SUBROUTINE SYMINV (APPLE-II VERSION)

```
DO 110 J=1,N
110 C(J)=-B(J)/D
C
L=1
C
DO 130 J=1,N
M=L
C
DO 120 K=J,N
A(L)=A(L)+B(J)*C(K)
C
115 CONTINUE
C
A(M)=A(L)
M=M+N
C
120 L=L+1
C
130 L=L+J
C
C(I)=-1.0E0/D
M=I
C
DO 140 J=1,N
K=NR+J
C
```

SUBROUTINE SYMINV (APPLE-II VERSION)

```

C      A(K)=C(J)
C      A(M)=C(J)
C      140 M=M+N
C      NS=N*N
C      DO 150 J=1,NS
C      150 A(J)=-A(J)
C      DO 160 I=1,N
C      B(I)=ZRO
C      II=(I-1)*N
C      DO 160 J=1,N
C      JJ=II+J
C      160 B(I)=B(I)+ABS(A(JJ))
C      AINR=ZRO
C      DO 170 I=1,N
C      170 AINR=AMAX1(AINR,B(I))
C      CNBR=ANR*AINR
C      WRITE(6,2000) CNBR
C      RETURN

```

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SUBROUTINE SYMINV (APPLE-II VERSION)

```
C 180 IFLG=1
      RETURN
C 2000 FORMAT('SX,' CONDITION NUMBER',SX,1E15.5)
C
      END
```

```

SUBROUTINE MULT (APPLE-II VERSION)

C      SUBROUTINE MULT(A,B,C,NRA,NCA,NCB)
C
C      IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
C      DIMENSION A(1),B(1),C(1)
C
C      ZRO=0.0E0
C
C      DO 110 I=1,NRA
C      DO 110 J=1,NCB
C
C      IC=I+(J-1)*NRA
C      TEMP=ZRO
C
C      DO 100 K=1,NCA
C
C      IA=I+(K-1)*NRA
C      IB=K+(J-1)*NCA
C      TEMP=TEMP+A(IA)*B(IB)
C
C      100 CONTINUE
C
C      C(IC)=TEMP
C
C      110 CONTINUE
C
C      RETURN
C
C      END

```

```

SUBROUTINE RDDISK (APPLE-II VERSION)
C
SUBROUTINE RDDISK(NACTIV,C,NENTRY,NRECFY)
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
DIMENSION C(1)
C
IF(NACTIV.LE.NRECFY) IUNIT=7
IF((NACTIV.GT.NRECFY).AND.(NACTIV.LE.(2*NRECFY))) IUNIT=8
IF((NACTIV.GT.(2*NRECFY)).AND.(NACTIV.LE.(3*NRECFY))) IUNIT=9
IF((NACTIV.GT.(3*NRECFY)).AND.(NACTIV.LE.(4*NRECFY))) IUNIT=10
C
NRECRD=NACTIV-(IUNIT-7)*NRECFY
C
READ(IUNIT,REC=NRECRD,END=1000) (C(K),K=1,NENTRY)
C
RETURN
C
1000 CONTINUE
WRITE(6,1010) NACTIV
C
DO 1020 IUNIT=7,10,1
1020 CLOSE(IUNIT,STATUS='KEEP')
C
STOP
C
1010 FORMAT(/,5X,' PROGRAM ABORT !!!,/,', ' END OF FILE ENCOUNTERED DURING
1 READ OF BLOCK: ',115,/, ' ALL FILES CLOSED ...')
C
END

```

SUBROUTINE WRDISK (APPLE-II VERSION)

C SUBROUTINE WRDISK(NACTIV,C,NENTRY,NRECFY)

C IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C DIMENSION C(1)

IF(NACTIV.LE.NRECFY) IUNIT = 7

IF((NACTIV.GT.NRECFY).AND.(NACTIV.LE.(2*NRECFY))) IUNIT = 8

IF((NACTIV.GT.(2*NRECFY)).AND.(NACTIV.LE.(3*NRECFY))) IUNIT = 9

IF((NACTIV.GT.(3*NRECFY)).AND.(NACTIV.LE.(4*NRECFY))) IUNIT = 10

C NRECRD=NACTIV-(IUNIT-7)*NRECFY

C WRITE(IUNIT,REC=NRECRD) (C(K),K=1,NENTRY)

C RETURN

C END

```

SUBROUTINE TEST (APPLE-II VERSION)
C
SUBROUTINE TEST(NN,MM,NS,C,NRECFY)
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
DIMENSION C(1)
C
NCOUNT=NS**2
NEQN = NN * NS
NTRUHB = MM * NS
NBLTOT = NN * (MM + 1)
LRECS = NCOUNT * 4
C
DO 100 I=1,NCOUNT
100 C(I)=0.0E0
C
DO 125 I=1,NS
ENTRY=FLOAT(NS+1)*1.0E0
C
DO 125 J=1,NS
IJ=(I-1)*NS+J
JI=(J-1)*NS+I
ENTRY=ENTRY-1.0E0
C(IJ)=ENTRY
C
C 125 C(JI)=C(IJ)
C

```

SUBROUTINE TEST (APPLE-II VERSION)

```

WRITE(6,175)
WRITE(6,176) NS,NN,MM
WRITE(6,177) NEQN,NTRUHB,NBLTOT,LRECS
WRITE(6,200)
WRITE(6,225) (C(I), I=1,NCOUNT)
WRITE(6,180)

C
DO 250 I=1,NN
C
J = 1
C
NACTIV=(I-1)*(MM+2)+J-I+1
C
WRITE(6,181) NACTIV

C
CALL DISKWR(NACTIV,C,NCOUNT,NRECFY)
C
250 CONTINUE
C
DO 260 I=1,NS
DO 260 J=1,NS
C
IJ=(I-1)*NS+J
II=(I-1)*NS+I
C(IJ)=0.0E0
C(II)=2.0E0
C

```


SUBROUTINE TEST (APPLE-II VERSION)

```

260 CONTINUE
C
    WRITE(6,270)
    WRITE(6,225) (C(I), I=1, NCOUNT)
    WRITE(6,120)
C
    DO 280 I=1, NN
    DO 280 J=2, MM
C
        NACTIV=(I-1)*(MM+2)+J-I+1
C
        WRITE(6,181) NACTIV
C
        CALL DISKWR(NACTIV, C, NCOUNT, NRECFY)
C
    280 CONTINUE
C
    DO 290 I=1, NS
    C(I)=10.0E0
    290 CONTINUE
C
    WRITE(6,300)
    WRITE(6,225) (C(I), I=1, NS)
    WRITE(6,130)
C
    DO 310 I=1, NN
C
        NACTIV=I*(MM+1)

```

SUBROUTINE TEST (APPLE-II VERSION)

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```

C      WRITE(6,181) NACTIV
C
C      CALL DISKWR(NACTIV,C,NS,NRECFY)
C
C      310 CONTINUE
C
C      RETURN
C
180 FORMAT(/,3X,'DIAGONAL BLOCK NUMBERS GENERATED AND WRITTEN:',/)
181 FORMAT(1X,115%)
120 FORMAT(/,3X,'OFF-DIAGONAL BLOCK NUMBERS GENERATED AND WRITTEN:',/)
130 FORMAT(/,3X,'R. H. S. BLOCK NUMBERS GENERATED AND WRITTEN:',/)
175 FORMAT(3X,'BLOCK SOLVER TEST RUN DATA:',/,/)
176 FORMAT(3X,'SUBMATRIX BLOCKSIZE (NS):',115,/,
1      3X,'NUMBER OF ROWS OF BLOCKS (NN):',115,/,
2      3X,'BLOCK HALF BANDWIDTH (MM):',115,/,
177 FORMAT(3X,'NUMBER OF EQUATIONS:',115,/,
1      3X,'TRUE HALF BANDWIDTH:',115,/,
2      3X,'TOTAL NUMBER OF BLOCKS:',115,/,
3      3X,'BLOCKSIZE/RECORD LENGTH (BYTES):',115,/)
200 FORMAT(3X,'DIAGONAL BLOCKS:',/,/)
225 FORMAT(8(1F9.1,1X))
270 FORMAT(/,3X,'OFF-DIAGONAL BLOCKS:',/,/)
300 FORMAT(/,3X,'R.H.S. MEMBERS:',/,/)
C
      END
SUBROUTINE DISKWR(NACTIV,C,NENTRY,NRECFY)

```

SUBROUTINE TEST (APPLE-II VERSION)

```

C
C      IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
C      DIMENSION C(1)
C
C      IF(NACTIV.LE.NRECFY) IUNIT = 7
C      IF((NACTIV.GT.NRECFY).AND.(NACTIV.LE.(2*NRECFY))) IUNIT = 8
C      IF((NACTIV.GT.(2*NRECFY)).AND.(NACTIV.LE.(3*NRECFY))) IUNIT = 9
C      IF((NACTIV.GT.(3*NRECFY)).AND.(NACTIV.LE.(4*NRECFY))) IUNIT = 10
C
C      NRECRD=NACTIV-(IUNIT-7)*NRECFY
C
C      WRITE(*,100) NACTIV,IUNIT,NRECRD
C
C      WRITE(IUNIT,REC=NRECRD) (C(K),K=1,NENTRY)
C
C      RETURN
C
C      100 FORMAT(/,' DISKWR ENTERED !!!',/, ' BLOCK: ',115,
C      1 ' UNIT: ',115,' RECORD: ',115)
C
C      END

```

```

SUBROUTINE ANSWER (APPLE-II VERSION)

C
SUBROUTINE ANSWER(NN,MM,NS,C,NRECFY)
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
DIMENSION C(1)
C
WRITE(*,'(A)') ' ANSWER ENTERED !!!'
C
WRITE(6,25)
C
DO 50 I=1,NN
C
NACTIV=I*(MM+1)
C
CALL DISKRD(NACTIV,C,NS,NRECFY)
C
WRITE(6,75) NACTIV
WRITE(6,100) (C(J),J=1,NS)
C
50 CONTINUE
C
WRITE(*,'(A)') ' DEPARTING ANSWER !!!'
C
RETURN
C
25 FORMAT(/,3X,' ANSWERS:',/)
75 FORMAT(/,' FROM BLOCK --> ',I15,/)
100 FORMAT(4(1E12.5,1X))

```

SUBROUTINE ANSWER (APPLE-II VERSION)

```

C
END
SUBROUTINE DISKRD(NACTIV,C,NENTRY,NRECFY)
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
DIMENSION C(1)
C
IF(NACTIV.LE.NRECFY) IUNIT=7
IF((NACTIV.GT.NRECFY).AND.(NACTIV.LE.(2*NRECFY))) IUNIT=8
IF((NACTIV.GT.(2*NRECFY)).AND.(NACTIV.LE.(3*NRECFY))) IUNIT=9
IF((NACTIV.GT.(3*NRECFY)).AND.(NACTIV.LE.(4*NRECFY))) IUNIT=10
C
NRECRD=NACTIV-(IUNIT-7)*NRECFY
C
WRITE(*,900) NACTIV,IUNIT,NRECRD
C
READ(IUNIT,REC=NRECRD,END=1000) (C(K),K=1,NENTRY)
C
RETURN
C
1000 CONTINUE
WRITE(6,1010) NACTIV
C
DO 1020 IUNIT=7,10,1
1020 CLOSE(IUNIT,STATUS='KEEP')
C
STOP

```

SUBROUTINE ANSWER (APPLE-II VERSION)

```

C  900 FORMAT(/, ' DISKRD ENTERED !!!',/, ' BLOCK: ',115,
1  ' UNIT: ',115, ' RECORD: ',115)
1010 FORMAT(/,5X, ' PROGRAM ABORT !!!',/, ' END OF FILE ENCOUNTERED DURING
1  READ OF BLOCK: ',115,/, ' ALL FILES CLOSED ...')
C
END

```

```

PROGRAM THESIS (FOR THE APPLE-II)

$USES UANSWER IN SCRATCH:ANSWER.CODE OVERLAY
$USES USOLVE IN SCRATCH:SOLVE.CODE OVERLAY
$USES UFILES IN SCRATCH:FILES.CODE OVERLAY
$USES UTEST IN SCRATCH:TEST.CODE OVERLAY
C

PROGRAM THESIS
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
CHARACTER*23 FNAME1,FNAME2,FNAME3,FNAME4
C
COMMON SPACE(3000)
C
OPEN(*,FILE='CONSOLE:')
C
5 WRITE(*,'(A)') 'ENTER THE NUMBER OF ROWS OF BLOCKS'
  READ(*,10) NN
  IF(NN.EQ.0) NN = 1
  IF(NN.GE.1) GO TO 15
  GO TO 5
C
15 WRITE(*,'(A)') 'ENTER THE NUMBER OF COLUMNS OF BLOCKS'
  READ(*,10) MM
  IF(MM.EQ.0) MM = 1
  IF((MM.LE.NN).AND.(MM.GE.1)) GO TO 20
  GO TO 15
C
20 WRITE(*,'(A)') 'WHAT IS THE SQUARE BLOCKSIZE ?'

```

PROGRAM THESIS (FOR THE APPLE-II)

```

      READ(*,10) NS
      IF(NS.EQ.0) NS = 8
      IF((NS.GE.1).AND.(NS.LE.32)) GO TO 25
      GO TO 20

C
25 WRITE(*,'(A)') 'WHAT'S THE FIRST FILE ? (DISK): (FILENAME)'.
   1(FILETYPE)'
      READ(*,'(A)') FNAME1
      IF(FNAME1.EQ.' ') FNAME1 = 'STIFF:1'
35 WRITE(*,'(A)') 'WHAT'S THE SECOND FILENAME ? (DISK): (FILENAME)'.
   1(FILETYPE)'
      READ(*,'(A)') FNAME2
      IF(FNAME2.EQ.' ') FNAME2 = 'STIFF:2'
45 WRITE(*,'(A)') 'WHAT'S THE THIRD FILENAME ? (DISK): (FILENAME)'.
   1(FILETYPE)'
      READ(*,'(A)') FNAME3
      IF(FNAME3.EQ.' ') FNAME3 = 'STIFF:3'
55 WRITE(*,'(A)') 'WHAT'S THE FOURTH FILENAME ? (DISK): (FILENAME)'.
   1(FILETYPE)'
      READ(*,'(A)') FNAME4
      IF(FNAME4.EQ.' ') FNAME4 = 'STIFF:4'

      LRECS=(NS**2)*4

C
      OPEN(6,FILE='PRINTER:')

C
      NCOUNT=NS**2
      NAK1=1

```


PROGRAM THESIS (FOR THE APPLE-II)

NAK2=NAK1+NCOUNT
NAK3=NAK2+NCOUNT
NRB1=NAK3+NCOUNT
NRB2=NRB1+NS
NRB3=NRB2+NS
NLAST=NRB3+NS

IF (NLAAT.GT.3000) GO TO 5000

CALL FILES(NN,MM,LRECS,FNAME1,FNAME2,FNAME3,FNAME4,NRECFY)
CALL TEST(NN,MM,NS,SPACE(NAK1),NRECFY)
CALL SOLVE(NN,MM,NS,SPACE(NAK1),SPACE(NAK2),SPACE(NAK3),
1SPACE(NRB1),SPACE(NRB2),SPACE(NRB3),NRECFY)
CALL ANSWER(NN,MM,NS,SPACE(NRB3),NRECFY)

STOP

5000 WRITE(*,'(A)') 'STORAGE CAPACITY EXCEEDED !!! PROGRAM ABORT.'

STOP

10 FORMAT(112)

END

SUBROUTINE FILES (APPLE-II VERSION)

SUBROUTINE FILES(NN,MM,LRECS,FNAME1,FNAME2,FNAME3,FNAME4,NRECFY)

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

CHARACTER*23 FNAME1,FNAME2,FNAME3,FNAME4

WRITE(*,'(A)') ' FILES ENTERED !!!'

BLTOT=FLOAT(NN*(MM+1))

BYTOT=BLTOT*FLOAT(LRECS)

BYMAX=(2.0**15)*4.0

IF (BYTOT.GT.BYMAX) GO TO 1000

NRECFY=INT(BYMAX/(FLOAT(LRECS)*4.0))

OPEN(7,FILE=FNAME1,ACCESS='DIRECT',FORM='UNFORMATTED',
1STATUS='OLD',RECL=LRECS)

OPEN(8,FILE=FNAME2,ACCESS='DIRECT',FORM='UNFORMATTED',
1STATUS='OLD',RECL=LRECS)

OPEN(9,FILE=FNAME3,ACCESS='DIRECT',FORM='UNFORMATTED',
1STATUS='OLD',RECL=LRECS)

OPEN(10,FILE=FNAME4,ACCESS='DIRECT',FORM='UNFORMATTED',
1STATUS='OLD',RECL=LRECS)

WRITE(*,'(A)') ' DEPARTING FILES !!!'

RETURN

SUBROUTINE FILES (APPLE-II VERSION)

```

C      1000 CONTINUE
C
C      WRITE(6,1010) BYMAX,BYTOT
C
C      STOP
C
C      1010 FORMAT(/, ' THERE ARE A MAXIMUM OF', 1X, 1E12.0, 1X, 'BYTES', /,
C      1' ALLOWED FOR A PROBLEM. YOU HAVE ATTEMPTED A', /,
C      2' PROBLEM REQUIRING', 1X, 1E12.0, 1X, 'BYTES.', /,
C      3' SOLUTION OF EQUATIONS ABORTED !!!')
C
C      END

```

APPENDIX E

SAMPLE EQUATION SOLUTION - APPLE-II PLUS PERSONAL COMPUTER

BLOCK SOLVER TEST RUN DATA:

SUBMATRIX BLOCKSIZE (NS): 8
 NUMBER OF ROWS OF BLOCKS (NN): 20
 BLOCK HALF BANDWIDTH (MM): 8
 NUMBER OF EQUATIONS: 160
 TRUE HALF BANDWIDTH: 64
 TOTAL NUMBER OF BLOCKS: 180
 BLOCKSIZE/RECORD LENGTH (BYTES): 256

DIAGONAL BLOCKS:

8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0
7.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0
6.0	7.0	8.0	7.0	6.0	5.0	4.0	3.0

5.0	6.0	7.0	8.0	7.0	6.0	5.0	4.0
4.0	5.0	6.0	7.0	8.0	7.0	6.0	5.0
3.0	4.0	5.0	6.0	7.0	8.0	7.0	6.0
2.0	3.0	4.0	5.0	6.0	7.0	8.0	7.0
1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0

DIAGONAL BLOCK NUMBERS GENERATED AND WRITTEN:

1 10 19 28 37 46 55 64 73 82 91 100 109
 118 127 136 145 154 163 172

OFF-DIAGONAL BLOCKS:

2.0	.0	.0	.0	.0	.0	.0	.0
.0	2.0	.0	.0	.0	.0	.0	.0
.0	.0	2.0	.0	.0	.0	.0	.0
.0	.0	.0	2.0	.0	.0	.0	.0
.0	.0	.0	.0	2.0	.0	.0	.0
.0	.0	.0	.0	.0	2.0	.0	.0
.0	.0	.0	.0	.0	.0	2.0	.0
.0	.0	.0	.0	.0	.0	.0	2.0

CONDITION NUMBER	.96000E+02
CONDITION NUMBER	.71231E+02
CONDITION NUMBER	.10207E+03
CONDITION NUMBER	.11644E+03
CONDITION NUMBER	.12474E+03
CONDITION NUMBER	.13011E+03
CONDITION NUMBER	.13385E+03
CONDITION NUMBER	.13660E+03
CONDITION NUMBER	.60042E+02
CONDITION NUMBER	.12585E+03
CONDITION NUMBER	.20560E+04
CONDITION NUMBER	.23597E+03

CONDITION NUMBER	.15804E+03
CONDITION NUMBER	.48754E+03
CONDITION NUMBER	.34217E+03
CONDITION NUMBER	.31243E+04
CONDITION NUMBER	.86782E+02
CONDITION NUMBER	.57805E+02
CONDITION NUMBER	.21690E+03
CONDITION NUMBER	.68632E+02

ANSWERS:

FROM BLOCK -->	9			
.27975E+00	.19845E+00	.15354E+00	.11678E+00	
.11693E+00	.15348E+00	.19834E+00	.27985E+00	
FROM BLOCK -->	18			
.34596E+00	.16645E+00	.11091E+00	.11342E+00	
.11326E+00	.11100E+00	.16647E+00	.34593E+00	
FROM BLOCK -->	27			
.32996E+00	.16629E+00	.10752E+00	.10520E+00	
.10540E+00	.10752E+00	.16631E+00	.32990E+00	
FROM BLOCK -->	36			
.31393E+00	.16616E+00	.10404E+00	.97296E-01	
.97174E-01	.10410E+00	.16622E+00	.31388E+00	

FROM BLOCK --> 45

.37966E+00	.13426E+00	.61589E-01	.93854E-01
.94054E-01	.61673E-01	.13403E+00	.37977E+00

FROM BLOCK --> 54

-.46983E-01	.20397E+00	.29E47E+00	.10030E+00
.10002E+00	.29638E+00	.20415E+00	-.47028E-01

FROM BLOCK --> 63

.21453E+00	.45164E-01	.78499E-02	.29660E+00
.29637E+00	.77530E-02	.45467E-01	.21438E+00

FROM BLOCK --> 72

.94469E-01	.28042E+00	.20400E+00	-.31112E-01
-.30759E-01	.20399E+00	.28012E+00	.94653E-01

FROM BLOCK --> 81

.11954E+00	.99401E-01	.13483E+00	.17755E+00
.17732E+00	.13492E+00	.99465E-01	.11948E+00

FROM BLOCK --> 90

.10840E+00	.13588E+00	.14415E+00	.14741E+00
.14765E+00	.14404E+00	.13589E+00	.10840E+00

FROM BLOCK --> 99

.10839E+00	.13591E+00	.14405E+00	.14764E+00
.14742E+00	.14412E+00	.13592E+00	.10837E+00

FROM BLOCK --> 108

.11957E+00	.99620E-01	.13485E+00	.17719E+00
.17740E+00	.13486E+00	.99440E-01	.11966E+00

FROM BLOCK --> 117

.94481E-01	.28000E+00	.20405E+00	-.30626E-01
-.30896E-01	.20400E+00	.28028E+00	.94372E-01

FROM BLOCK --> 126

.21456E+00	.45323E-01	.78041E-02	.29640E+00
.29642E+00	.77691E-02	.45411E-01	.21451E+00

FROM BLOCK --> 135

-.47239E-01	.20419E+00	.29644E+00	.10008E+00
.10045E+00	.29648E+00	.20381E+00	-.47021E-01

FROM BLOCK --> 144

.37967E+00	.13399E+00	.61620E-01	.94208E-01
.93968E-01	.61635E-01	.13409E+00	.37962E+00

FROM BLOCK --> 153

.31385E+00	.16616E+00	.10413E+00	.97191E-01
.97354E-01	.10407E+00	.16616E+00	.31385E+00

FROM BLOCK --> 162

.32994E+00	.16631E+00	.10745E+00	.10536E+00
.10523E+00	.10757E+00	.16632E+00	.32990E+00

FROM BLOCK --> 171

.34594E+00	.16648E+00	.11095E+00	.11325E+00
.11344E+00	.11096E+00	.16643E+00	.34593E+00

FROM BLOCK --> 180

.28005E+00	.19851E+00	.15349E+00	.11670E+00
.11648E+00	.15341E+00	.19852E+00	.28003E+00

APPENDIX F

STAP-NPS PROGRAM LISTING

PAGE: 1

PROGRAM PROBLEM (APPLE-II PLUS)

C...!.*.1+0...!.2+0...!.3+0...!.4+0...!.5+0...!.6+0...!.7+0...!.....

\$USES UINPUT IN DEVEL:INPUT.CODE OVERLAY
\$USES URWCOMN IN DEVEL:RWCOMN.CODE OVERLAY
\$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
PROGRAM PROBLEM

C IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C CHARACTER*23 FNAME1,FNAME2
CHARACTER*4 SPK(2),TALK,HED(20)
CHARACTER*1 ANSWER,AFFIRM

C COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK
COMMON /FREQIF/ ISTOH,ISTOTE
COMMON /MDFRDM/ IDOF(6)
COMMON /VAR/ NG,MODEX
COMMON /LONGER/ LONG
COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(2000)
COMMON /IWORK/ IA(2000)

C DATA AFFIRM,'Y' /

PROGRAM PROBLEM (APPLE-II PLUS)

```

C
    SPK(1) = 'FRAN'
    SPK(2) = 'ENGL'
C
    ICOM = 7
    IIN = 5
    IOUT = 6
    IRIG = 4
    IDTAP = 3
    ILOAD = 2
    IELMNT = 1
C
    WRITE(*,'(A)') 'PROBLEM VERSION 2.0 22 MAR 82'
    WRITE(*,'(A)') 'ENTER (DISK): (FILENAME).TEXT !!!'
    READ(*,'(A)') FNAME1
    WRITE(*,'(A)') '(CONSOLE:$) OR (PRINTER:$) OUTPUT ???'
    READ(*,'(A)') FNAME2
C
    WRITE(*,'(A)') '----> OPENING FILES !!!'
C
    OPEN(3,FILE='#11:IDTAP',ACCESS='SEQUENTIAL',STATUS='NEW',
    1FORM='UNFORMATTED')
    OPEN(5,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='OLD',
    1FORM='FORMATTED')
    OPEN(6,FILE=FNAME2,ACCESS='SEQUENTIAL',STATUS='NEW',
    1FORM='FORMATTED')
    OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='NEW',

```

PROGRAM PROBLEM (APPLE-II PLUS)

1FORM='UNFORMATTED')

C

MTOTR = 2000
MTOTI = 2000
LONG = 512
MBLOCK = 64

C

100 NUMEST = 0
MAXEST = 0
NBCEL = 0
NWK = 0
NWM = 0
NWC = 0
MIDEST = 0
MA = 0
IND = 0
DO 8 I = 1,3
8 NPAR(I) = 0
NBRLOD = 0
KTR = 0
NEQL = 0
NEQR = 0
MLA = 0
NBLOCK = 0
ISTOH = 0
ISTOTE = 0
NG = 0
DO 9 I = 1,MTOTI

PROGRAM PROBLEM (APPLE-II PLUS)

```

9  IA(I) = 0
DO 10 I = 1, MTOTR
10  A(I) = 0
C
C  REWIND(IIN)
C
C  READ( IIN, 1000, END=800 ) TALK
C  IF(TALK.NE.SPK(1)) TALK = SPK(2)
C  READ(IIN,1000) (HED(I), I=1,20)
C  READ( IIN, 1001 ) NUMNP, (IDOF(I), I=1,6), NUMEG, NLCASE, MODEX, ISTOTE
C
C  IF( NUMNP .GT. 0 ) GO TO 750
C
C  IF(TALK.EQ.SPK(1)) WRITE( IOUT, 3020)
C  IF(TALK.EQ.SPK(2)) WRITE( IOUT, 3021)
C
800 STOP
C
750 CONTINUE
C
C  NDOF = 6
C  DO 150 I = 1,6
150  NDOF = NDOF - IDOF( I )
C
C  IF(TALK.EQ.SPK(1)) WRITE( IOUT,2000 ) (HED(I), I=1,20), NUMNP,
1  NDOF, NUMEG, NLCASE
C  IF(TALK.EQ.SPK(2)) WRITE( IOUT,2001 ) (HED(I), I=1,20), NUMNP,
1  NDOF, NUMEG, NLCASE

```

PROGRAM PROBLEM (APPLE-II PLUS)

```
IF(TALK.EQ.SPK(1)) WRITE( IOUT,2010 ) MODEX, ISTOTE
IF(TALK.EQ.SPK(2)) WRITE( IOUT,2011 ) MODEX, ISTOTE
```

C

```
NR1 = 1
NR2 = NR1 + NUMNP
NR3 = NR2 + NUMNP
NR4 = NR3 + NUMNP
NENDR = NR4
```

C

```
NI1 = 1
NI2 = NI1 + NDOF * NUMNP
NENDI = NI2
```

C

```
NFIRST = 0
NLAST = 0
```

C

```
IF( NR4 .GT. MTOTR ) CALL ERROR( N5 - MTOT, 1, 1 )
IF( NI2 .GT. MTOTI ) CALL ERROR( N5 - MTOT, 1, 2 )
```

C

```
CALL INPUT( IA(NI1), A(NR1), A(NR2), A(NR3), NUMNP, NDOF, NEQ )
```

C

```
NEQ1 = NEQ + 1
```

C

```
REWIND IDTAP
```

```
IF( MODEX .NE. 0 ) WRITE( IDTAP ) ( IA( I ), I = NI1, NI2-1 )
```

C

```
WRITE(*,'(A)') '----' WRITING INTO DATABASE ALL COMMON'
WRITE(*,'(A)') '    VARIABLES AND ENTIRE WORKSPACE !!!'
```

PROGRAM PROBLEM (APPLE-II PLUS)

CALL RWCOMM(2)

C

CLOSE(3, STATUS='KEEP')
CLOSE(5, STATUS='KEEP')
CLOSE(6)
CLOSE(7, STATUS='KEEP')
WRITE(*, '(A)') '----' FILES CLOSED, NORMAL TERMINATION.'

C

WRITE(*, '(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
READ(*, '(A)') ANSWER
IF(ANSWER .EQ. AFFIRM) GO TO 999

C

WRITE(*, '(A)') '---' DIAGNOSTICS:
WRITE(*, '(A)') '---' ID ARRAY:
WRITE(*, 8989) (I, IA(I), I=NI1, NI2-1)
WRITE(*, '(A)') '---' X ARRAY:
WRITE(*, 9898) (I, A(I), I=NR1, NR2-1)
WRITE(*, '(A)') '---' Y ARRAY:
WRITE(*, 9898) (I, A(I), I=NR2, NR3-1)
WRITE(*, '(A)') '---' Z ARRAY:
WRITE(*, 9898) (I, A(I), I=NR3, NR4-1)

C

999 STOP

C

1000 FORMAT(20A4)
1001 FORMAT(1I5,6I1,1I4,3I5)
2000 FORMAT('1',/, ' ', 20A4, /,

A' P A R A M E T R E S D E C O N T R O L E :

,/,

B' NOMBRE DE POINTS NODAUX (NUMNP) =',15,/,
 C' NOMBRE DE DEGRES DE LIBERTES PAR NOEUD (NDOF) =',15,/,
 D' NOMBRE DE GROUPES D ELEMENT (NUMEG) =',15,/,
 E' NOMBRE DE CAS DE CHARGEMENT (NLCASE) =',15,/,
 F)

2001 FORMAT('1',/,',',20A4,/,

A' C O N T R O L P A R A M E T E R S :

B' NUMBER OF NODAL POINTS. (NUMNP) =',15,/,
 C' NUMBER OF DEGREES OF FREEDOM PER NODE (NDOF) =',15,/,
 D' NUMBER OF ELEMENT GROUPS. (NUMEG) =',15,/,
 E' NUMBER OF LOADING CASES (NLCASE) =',15,/,
 F)

2010 FORMAT(

G' MODE D EXECUTION DU PROGRAMME (MODEX) =',15,/,
 H' .EQ. 0 : VERIFICATION DES DONNEES SEULEMENT
 I' .EQ. 1 : SOLUTION DU PROBLEME
 J' NOMBRE DES TERMES DE LA MATRICE PAR BLOC. (ISTOTE) =',15,/,
 K' .EQ. 0 : PAR DEFAULT CALCULE PAR LE PROGRAMME BLOCKS
 2011 FORMAT(

G' MODE OF PROGRAM EXECUTION (MODEX) =',15,/,
 H' .EQ. 0 : VERIFICATION OF INPUT DATA
 I' .EQ. 1 : SOLUTION OF THE PROBLEM
 J' NUMBER OF COEFFICIENTS PER BLOCK (ISTOTE) =',15,/,
 K' .EQ. 0 : CALCULATED BY DEFAULT BY PROGRAM BLOCKS

3020 FORMAT(' ERREUR: NOMBRE DE NOEUDS NUMNP TROUVE NUL !!!')

3021 FORMAT(' IA(',115,')= ',116)

8989 FORMAT('A(',115,')= ',1E13.6)

PAGE: 8

PROGRAM PROBLEM (APPLE-II PLUS)

C

END

SUBROUTINE INPUT (APPLE-II PLUS)

C...!.*,1+0...!.2+0...!.3+0...!.4+0...!.5+0...!.6+0...!.7+0...!.....

C SUBROUTINE INPUT(ID, X, Y, Z, NUMNP, NDOF, NEQ)

C IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C CHARACTER*4 SPK(2), TALK

C COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM

C COMMON /MDFRDM/ IDOF(6)

C COMMON /SPEAK/ SPK, TALK

C DIMENSION X(1),Y(1),Z(1),ID(NDOF,1),IDT(6),IDTOLD(6)

C CHARACTER*1 IPRC(4), IPR, JPR, IT

C DATA IPRC / ' ', 'A', 'B', 'C' /

C DATA IPR, JPR, IT / ' ', ' ', ' ' /

C DATA ZE, UN, QS / 0.E0, 1.E0, 45.E0 /

C IPRINT = 1

C NOLD = 0

C ITOLD = 0

C N = 0

C KN = 0

C KNOLD = 0

C DUM = ZE

SUBROUTINE INPUT (APPLE-II PLUS)

```

C      IPR = IPRC( 1 )
      RAD = ATAN( UN ) / QS
C
10  READ( IIN, 1000 ) IT, N, JPR, (IDT(I), I=1, 6), X(N), Y(N), Z(N), KN
C
      IF( IPRINT .EQ. 51) IPRINT = 1
      IF( IPRINT .NE. 1) GO TO 11
C
      IF( TALK.EQ.SP(1) ) WRITE( IOUT, 2000 )
      IF( TALK.EQ.SP(2) ) WRITE( IOUT, 2010 )
      IF( TALK.EQ.SP(1) ) WRITE( IOUT, 2001 )
      IF( TALK.EQ.SP(2) ) WRITE( IOUT, 2011 )
C
11  WRITE( IOUT, 2002 ) N, (IDT(I), I=1, 6), X(N), Y(N), Z(N), KN, IT
C
      IF( N .EQ. 1 ) IPR = JPR
      IF( IT .EQ. IPRC(1) ) GO TO 12
C
      DUM = Z( N ) * RAD
      Z( N ) = Y( N ) * SIN( DUM )
      Y( N ) = Y( N ) * COS( DUM )
C
12  II = 0
      DO 15 I = 1, NDOF
13  II = II + 1
      IF( II .LE. 6 ) GO TO 14
      IF( TALK.EQ.SP(1) ) WRITE( IOUT, 3000 )
      IF( TALK.EQ.SP(2) ) WRITE( IOUT, 3010 )

```

SUBROUTINE INPUT (APPLE-II PLUS)

STOP

```

C      14 IF( IDOF(II) .EQ. 1 ) GO TO 13
      15 ID( I, N ) = IDT( II )
C
C      IF( NOLD .EQ. 0 ) GO TO 50
C
      II = 0
      DO 20 I = 1, NDOF
      16 II = II + 1
      IF( II .LE. 6 ) GO TO 18
      IF( TALK.EQ.SPK(1) ) WRITE( IOUT, 3000 )
      IF( TALK.EQ.SPK(2) ) WRITE( IOUT, 3010 )
      STOP
C
      18 IF( IDOF(II) .EQ. 1 ) GO TO 16
      IF( (IDT(II).EQ.0) .AND. (IDTOLD(II).LT.0) ) THEN
      ID(I,N) = ID(I,NOLD)
      IDT(II) = IDTOLD(II)
      ENDIF
      20 CONTINUE
C
      IF( KNOLD .EQ. 0 ) GO TO 50
      NUM = ( N - NOLD ) / KNOLD
      NUMN = NUM - 1
      IF( NUMN .LT. 1 ) GO TO 50
C
      XNUM = NUM

```


SUBROUTINE INPUT (APPLE-II PLUS)

DX = (X(N) - X(NOLD)) / XNUM
IF(IT .EQ. IPRC(1)) GO TO 21

C

ROLD = Y(NOLD) / COS(DUMOLD)
RNEW = Y(N) / COS(DUM)
DR = (RNEW - ROLD) / XNUM
DT = (DUM - DUMOLD) / XNUM

C

GO TO 22

C

21 DY = (Y(N) - Y(NOLD)) / XNUM
DZ = (Z(N) - Z(NOLD)) / XNUM

C

22 K = NOLD

DO 30 J = 1, NUMN

KK = K

K = K + KNOLD

X(K) = X(KK) + DX

IF(IT .EQ. IPRC(1)) GO TO 26

C

ROLD = ROLD + DR

DUMOLD = DUMOLD + DT

Y(K) = ROLD * COS(DUMOLD)

Z(K) = ROLD * SIN(DUMOLD)

GO TO 28

C

26 Y(K) = Y(KK) + DY

Z(K) = Z(KK) + DZ

SUBROUTINE INPUT (APPLE-II PLUS)

```

C      28 DO 30 I = 1, NDOF
        ID( I, K ) = ID( I, KK )
C      30 CONTINUE

C      50 NOLD = N
        KNOLD = KN
        DUMOLD = DUM

C      DO 60 I = 1, 6
        60 IDTOLD( I ) = IDT( I )

C      IPRINT = IPRINT + 1

C      IF( N .NE. NUMNP ) GO TO 10

C      IPRINT = 1

C      IF( ( IPR.EQ.IPRC(2) ) .OR. ( IPR.EQ.IPRC(4) ) ) GO TO 80

C      DO 75 N = 1, NUMNP

C      IF( IPRINT .EQ. 51 ) IPRINT = 1
        IF( IPRINT .NE. 1 ) GO TO 63

C      IF( TALK.EQ.SPK(1) ) WRITE( IOUT, 2000 )
        IF( TALK.EQ.SPK(2) ) WRITE( IOUT, 2010 )
        IF( TALK.EQ.SPK(1) ) WRITE( IOUT, 2003 )

```

SUBROUTINE INPUT (APPLE-II PLUS)

```

IF(TALK.EQ.SPK(2)) WRITE( IOUT, 2013 )
IF(TALK.EQ.SPK(1)) WRITE( IOUT, 2008 )
IF(TALK.EQ.SPK(2)) WRITE( IOUT, 2018 )

```

C

63 I = 1

C

```

DO 70 II = 1, 6
  IDT( II ) = IDOF( II )
  IF( IDOF( II ) .EQ. 1 ) GO TO 70
  IDT( II ) = ID( I, N )
  I = I + 1

```

70 CONTINUE

C

```

WRITE( IOUT, 2005 ) N, (IDT(I), I=1, 6), X(N), Y(N), Z(N)
IPRINT = IPRINT + 1

```

75 CONTINUE

C

IPRINT = 1

C

80 CONTINUE

NEQ = 0

```

DO 100 N = 1, NUMNP
  DO 100 I = 1, NDOF
    IF( ID(I,N) ) 110, 120, 110
    120 NEQ = NEQ + 1
    ID( I, N ) = NEQ

```

C

GO TO 100

SUBROUTINE INPUT (APPLE-II PLUS)

```

110 ID( I, N ) = 0
100 CONTINUE
C
IF( ( IPR.EQ.IPRC(3)) .OR. ( IPR.EQ.IPRC(4)) ) RETURN
C
DO 175 N = 1, NUMNP
C
IF(IPRINT .EQ. 51) IPRINT = 1
IF(IPRINT .NE. 1) GO TO 101
C
IF(TALK.EQ.SPK(1)) WRITE( IOUT, 2000 )
IF(TALK.EQ.SPK(2)) WRITE( IOUT, 2010 )
IF(TALK.EQ.SPK(1)) WRITE( IOUT, 2004 )
IF(TALK.EQ.SPK(2)) WRITE( IOUT, 2014 )
C
101 I = 1
C
DO 170 II = 1, 6
IDT( II ) = 0
C
IF( IDOF( II ) .EQ. 1 ) GO TO 170
C
IDT( II ) = ID( I, N )
I = I + 1
170 CONTINUE
C
IPRINT = IPRINT + 1
C

```

SUBROUTINE INPUT (APPLE-II PLUS)

```

175 WRITE( IOUT, 2006 ) N, (IDT(ICK), ICK=1,6)
C
      RETURN
C
1000 FORMAT( A1, I4, A1, I4, 5I5, 3F10.0, I5 )
2000 FORMAT('1 D O N N E S   D E S   N O E U D S :',/)
2010 FORMAT('1 N O D A L   P O I N T   I N F O R M A T I O N :',/)
2001 FORMAT(' NOEUDS DONNES',/, ' NOEUD CONDITIONS AUX LIMITES', 12X,
1' COORDONNEES DES NOEUDS', 7X, 'PAS COO',/, ' NUMERO',
2' U   V   W   XX   YY   ZZ', 7X, 'X', 12X, 'Y', 12X, 'Z')
2011 FORMAT(' GIVEN NODES   ',/, ' NODE   BOUNDARY CONDITIONS', 12X,
1' NODAL COORDINATES   ', 7X, 'PITCH C',/, ' NUMBER',
2' U   V   W   XX   YY   ZZ', 7X, 'X', 12X, 'Y', 12X, 'Z')
2002 FORMAT( 1X, I5, 3I4, I5, 2I4, 3E13.6, I4, 3X, A1 )
2003 FORMAT(' NOEUDS GENERES')
2013 FORMAT(' GENERATED NODES')
2004 FORMAT(' NOEUD
1' NUMERO      U      V      W      XX      YY      ZZ ')
2014 FORMAT(' NODE
1' NUMBER      U      V      W      XX      YY      ZZ ')
2005 FORMAT( 1X, I5, 3I4, I5, 2I4, 3E13.6 )
2006 FORMAT( 1X, I5, 3X, 5I6, 1I6)
2008 FORMAT(' NOEUD CONDITIONS AUX LIMITES ', 12X, 'COORDONNEES DES
1 NOEUDS',/, ' NUMERO U   V   W   XX   YY   ZZ', 7X, 'X', 12X, 'Y', 12X,
2 'Z')
2018 FORMAT(' NODE BOUNDARY CONDITIONS   ', 12X, 'NODAL COORDINATE
1S   ',/, ' NUMBER U   V   W   XX   YY   ZZ', 7X, 'X', 12X, 'Y', 12X,
2 'Z')

```

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SUBROUTINE INPUT (APPLE-II PLUS)

3000 FORMAT(' ERREUR: DEGRE DE LIBERTE PAR NOEUD ETANT MAUVAIS !')

3010 FORMAT(' ERROR: WRONG NUMBER OF D.O.F. OF FREEDOM PER NODE !')

C

END

SUBROUTINE RWCOMN (APPLE -II PLUS)

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!....

SUBROUTINE RWCOMN(IRORW)

C

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C

CHARACTER*4 SPK(2), TALK

C

COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK
COMMON /FREQIF/ ISTOH,ISTOTE
COMMON /MDFRDM/ IDOF(6)
COMMON /VAR/ NG,MODEX
COMMON /LONGER/ LONG
COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(1)
COMMON /IWORK/ IA(1)

C

REWIND ICOM

C

GO TO(1,2) IRORW

C

1 READ(ICOM) NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NR9,NR10,NR11,NR12,
ANUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA,IELMNT,ILOAD,IDTAP,

```

      BIRIG, IIN, IOUT, IDEC, ICOM, IND, (NPAR(I), I=1, 3), NUMEG, MTOTR, MTOTI,
      CNFIRST, NLAST, NBCEL, NEQ1, NEQL, NEQR, MLA, NBLOCK, ISTOH, (SPK(I), I=1, 2)
      READ(ICOM) NBRLOD, KTR, ISTOTE, MBLOCK, NENDR, NENDI,
      A NI1, NI2, NI3, NI4, NI5, NI6, NI7, NI8, NI9, NI10, NI11, NI12,
      B(IDOF(I), I=1, 6), NG, MODEX, LONG, NLCASE, TALK, NDOF

```

C

```

      READ(ICOM) (A(I), I=NR1, NENDR)
      READ(ICOM) (IA(I), I=NI1, NENDI)

```

C

RETURN

C

```

2  WRITE(ICOM) NR1, NR2, NR3, NR4, NR5, NRE, NR7, NR8, NR9, NR10, NR11, NR12,
      ANUMNP, NEQ, NWK, NWC, NUMEST, MIDEST, MAXEST, MA, IELMNT, ILOAD, IDTAP,
      BIRIG, IIN, IOUT, IDEC, ICOM, IND, (NPAR(I), I=1, 3), NUMEG, MTOTR, MTOTI,
      CNFIRST, NLAST, NBCEL, NEQ1, NEQL, NEQR, MLA, NBLOCK, ISTOH, (SPK(I), I=1, 2)
      WRITE(ICOM) NBRLOD, KTR, ISTOTE, MBLOCK, NENDR, NENDI,
      A NI1, NI2, NI3, NI4, NI5, NI6, NI7, NI8, NI9, NI10, NI11, NI12,
      B(IDOF(I), I=1, 6), NG, MODEX, LONG, NLCASE, TALK, NDOF

```

C

```

      WRITE(ICOM) (A(I), I=NR1, NENDR)
      WRITE(ICOM) (IA(I), I=NI1, NENDI)

```

C

RETURN

C

END

SUBROUTINE ERROR (APPLE-II PLUS)

C...!.*1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!...
SUBROUTINE ERROR(N, I, ITYPE)

C

CHARACTER*4 SPK(2), TALK

C

COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM
COMMON /SPEAK/ SPK, TALK

C

GO TO (1, 2, 3, 4, 5), I

C

1 IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2000)
IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2001)
GO TO 6

C

2 IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2010)
IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2011)
GO TO 6

C

3 IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2020)
IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2021)
GO TO 6

C

4 IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2030)
IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2031)
GO TO 6

C

5 IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2040)
IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2041)

SUBROUTINE ERROR (APPLE-II PLUS)

```

6 IF( (TALK.EQ.SPK(1)) .AND. (ITYPE .EQ. 1) ) THEN
  WRITE( IOUT, 2050 )
ENDIF
IF( (TALK.EQ.SPK(1)) .AND. (ITYPE .EQ. 2) ) THEN
  WRITE( IOUT, 2060 )
ENDIF
IF( (TALK.EQ.SPK(2)) .AND. (ITYPE .EQ. 1) ) THEN
  WRITE( IOUT, 2051 )
ENDIF
IF( (TALK.EQ.SPK(2)) .AND. (ITYPE .EQ. 2) ) THEN
  WRITE( IOUT, 2061 )
ENDIF

```

C

STOP

C

```

2000 FORMAT(' PAS ASSEZ DE MEMOIRE POUR LIRE LES NOEUDS' )
2001 FORMAT(' NOT ENOUGH MEMORY TO READ IN THE NODES ' )
2010 FORMAT(' PAS ASSEZ DE MEMOIRE POUR LIRE LES ELEMENTS' )
2011 FORMAT(' NOT ENOUGH MEMORY TO READ IN THE ELEMENTS ' )
2020 FORMAT(' PAS ASSEZ DE MEMOIRE POUR DEFINIR LE CHARGEMENT' )
2021 FORMAT(' NOT ENOUGH MEMORY TO READ IN LOADING INFORMATION' )
2030 FORMAT(' PAS ASSEZ DE MEMOIRE POUR FAIRE L ASSEMBLAGE' )
2031 FORMAT(' NOT ENOUGH MEMORY TO ASSEMBLE THE GLOBAL MATRIX' )
2040 FORMAT(' PAS ASSEZ DE MEMOIRE POUR FAIRE LA RESOLUTION' )
2041 FORMAT(' NOT ENOUGH MEMORY TO SOLVE SYSTEM OF EQUATIONS' )
2050 FORMAT(' DEPASSMENT DE MTOIR DE : ', IS)
2051 FORMAT(' MUST INCREASE MTOIR BY : ', IS)
2060 FORMAT(' DEPASSMENT DE MTOI DE : ', IS)

```

PAGE: 3

SUBROUTINE ERROR (APPLE-II PLUS)

2061 FORMAT(' MUST INCREASE MTOTI BY : ',15)
C

END

PROGRAM ELEMS (APPLE-II PLUS)

PAGE: 1

```

C...!.*..1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!.....
$USES UCOLHT IN DEVEL:COLHT.CODE OVERLAY
$USES URUSS1 IN DEVEL:RUSS1.CODE OVERLAY
$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
$USES UTRUSS1 IN DEVEL:TRUSS1.CODE OVERLAY
$USES UUELEMN1 IN DEVEL:ELEMN1.CODE OVERLAY
$USES UELCAL IN DEVEL:ELCAL.CODE OVERLAY
$USES URWCOMN IN DEVEL:RWCOMN.CODE OVERLAY
C
PROGRAM ELEMS
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
CHARACTER*23 FNAME1,FNAME2
CHARACTER*4 SPK(2),TALK
CHARACTER*1 ANSWER,AFFIRM
C
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK
COMMON /FREQIF/ ISTOH,ISTOTE
COMMON /MDFRDM/ IDOF(6)
COMMON /VAR/ NG,MODEX
COMMON /LONGER/ LONG

```

PROGRAM ELEM (APPLE-II PLUS)

COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(2000)
COMMON /IWORK/ IA(2000)

DATA AFFIRM/'Y' /

WRITE(*,'(A)') 'ELEMENT VERSION 2.0 23 MAR 82'
WRITE(*,'(A)') 'ENTER (DISK):(FILENAME).TEXT !!!'
READ(*,'(A)') FNAME1
WRITE(*,'(A)') '(CONSOLE:\$) OR (PRINTER:\$) OUTPUT ???'
READ(*,'(A)') FNAME2

WRITE(*,'(A)') '---> OPENING FILES !!!'

OPEN(1,FILE='#11:IELMNT',ACCESS='SEQUENTIAL',STATUS='NEW',
1FORM='UNFORMATTED')
OPEN(5,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='OLD',
1FORM='FORMATTED')
OPEN(6,FILE=FNAME2,ACCESS='SEQUENTIAL',STATUS='NEW',
1FORM='FORMATTED')
OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='OLD',
1FORM='UNFORMATTED')

ICOM = 7

WRITE(*,'(A)') '---> READING FROM DATABASE ALL COMMON'
WRITE(*,'(A)') ' VARIABLES AND ENTIRE WORKSPACE !!!'

PROGRAM ELEMS (APPLE-II PLUS)

```

C      CALL RWCOMN( 1 )

      WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
      READ(*,'(A)') ANSWER
      IF( ANSWER.EQ. AFFIRM ) GO TO 888

C      WRITE(*,'(A)') '----> DIAGNOSTICS:'
      WRITE(*,'(A)') '--> ID ARRAY:'
      WRITE(*,8889) (I,IA(I),I=NI1,NI2-1)
      WRITE(*,'(A)') '--> X ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)
      WRITE(*,'(A)') '--> Y ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)
      WRITE(*,'(A)') '--> Z ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)

C      888 IND = 1

C      WRITE(*,'(A)') '----> WRITING ELEMENT INFORMATION'
      WRITE(*,'(A)') '      INTO FILE IELMNT !!!'
      CALL ELCAL
      CLOSE(1,STATUS='KEEP')

C      CALL ADDRESS( IA(NI3), IA(NI2) )

C      CLOSE(7,STATUS='DELETE')
      OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='UNFORMATTED')

```

PROGRAM ELEM (APPLE-II PLUS)

```

WRITE(*,'(A)') '----' WRITING INTO DATABASE ALL COMMON'
WRITE(*,'(A)') '  VARIABLES AND ENTIRE WORKSPACE !!!'
CALL RWCOMM( 2 )

C
CLOSE(5,STATUS='KEEP')
CLOSE(6)
CLOSE(7,STATUS='KEEP')

C
WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
READ(*,'(A)') ANSWER
IF( ANSWER.EQ. AFFIRM ) GO TO 999

C
WRITE(*,'(A)') 'ID ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)

C
WRITE(*,'(A)') 'MHT ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)

C
WRITE(*,'(A)') 'MAXA ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)

C
WRITE(*,'(A)') 'LM ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)

C
WRITE(*,'(A)') 'MATP ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)

C

```

PROGRAM ELEMS (APPLE-II PLUS)

```

WRITE(*,'(A)') 'E ARRAY:'
WRITE(*,9898) (I,A(I),I=NR4,NR5-1)
C
WRITE(*,'(A)') 'AREA ARRAY:'
WRITE(*,9898) (I,A(I),I=NR5,NR6-1)
C
WRITE(*,'(A)') 'XYZ ARRAY:'
WRITE(*,9898) (I,A(I),I=NR6,NR7-1)
C
999 STOP
C
8989 FORMAT('IA',115,')= ',116)
9898 FORMAT('A',115,')= ',1E15.6)
C
END
$INCLUDE DEVEL:ADDRES.TEXT

```


SUBROUTINE ADDRESS (APPLE-II PLUS)

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!......

SUBROUTINE ADDRESS(MAXA, MHT)

C

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C

COMMON /SOL/ NUMNP, NEQ, NWK, NWM, NWC, NUMEST, MIDEST, MAXEST, MA

C

DIMENSION MAXA(1), MHT(1)

C

NN = NEQ + 1

DO 20 I = 1, NN

20 MAXA(I) = 0

C

MAXA(1) = 1

MAXA(2) = 2

MA = 0

IF(NEQ .EQ. 1) GO TO 100

C

DO 10 I = 2, NEQ

IF(MHT(I) .GT. MA) MA = MHT(I)

MAXA(I+1) = MAXA(I) + MHT(I) + 1

10 CONTINUE

100 MA = MA + 1

C

NWK = MAXA(NEQ+1) - MAXA(1)

C

RETURN

C

PAGE: 2

SUBROUTINE ADDRES (APPLE-II PLUS)

END

SUBROUTINE ELCAL (APPLE-II PLUS)

C...!*.1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!.....

\$USES UCOLHT IN DEVEL:COLHT.CODE OVERLAY
 \$USES URUSS1 IN DEVEL:RUSS1.CODE OVERLAY
 \$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
 \$USES UTRUSS1 IN DEVEL:TRUSS1.CODE OVERLAY
 \$USES UELEMN1 IN DEVEL:ELEMN1.CODE OVERLAY

C

SUBROUTINE ELCAL

C

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C

CHARACTER*4 SPK(2), TALK, BLOCK, LABEL

C

COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
 COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
 COMMON /SOL/ NUMNP,NEG,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
 COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
 COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
 COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
 COMMON /VAR/ NG,MODEX
 COMMON /SPEAK/ SPK,TALK
 COMMON /RWORK/ A(1)
 COMMON /IWORK/ IA(1)

C

REWIND IIN

REWIND IELMNT

C

BLOCK = 'ELEM'

SUBROUTINE ELCAL (APPLE-II PLUS)

```

C      WRITE( IOUT, 2010 )
C
999 READ(IIN,1001,END=888) LABEL
   IF(LABEL .NE. BLOCK) GO TO 999
C
   IF(TALK .EQ. SPK(1)) WRITE( IOUT, 2000 )
   IF(TALK .EQ. SPK(2)) WRITE( IOUT, 2001 )
C
DO 100 N = 1, NUMEG
C
   NG = N
C
   READ( IIN, 1000 ) (NPAR(I), I=1,3)
C
   CALL ELEMN1
C
   IF(MIDEST.GT.MAXEST) MAXEST = MIDEST
C
   IF(MODEX .NE. 0) WRITE(IELMNT) MIDEST, (NPAR(I), I=1,3),
1 (A(I), I=NR4, NR7-1), (IA(I), I=NI4, NI6-1)
C
100 CONTINUE
C
   RETURN
C
888 IF(TALK .EQ. SPK(1)) WRITE(IOUT,1002) BLOCK
   IF(TALK .EQ. SPK(2)) WRITE(IOUT,1012) BLOCK

```

SUBROUTINE ELCAL (APPLE-II PLUS)

```

C      STOP
      1000 FORMAT( 10I5 )
      1001 FORMAT( 1A4 )
      1002 FORMAT(/, ' ERROR: ', 1A4, ' INPUT DATA BLOCK NOT FOUND.', '/')
      1012 FORMAT(/, ' ERROR: ', 1A4, ' INPUT DATA BLOCK NOT FOUND.', '/')
      2000 FORMAT(' DONEES DES GROUPE S D EL. ', '/')
      2001 FORMAT(' INPUT FOR ELEMENT GROUPS :', '/')
      2010 FORMAT(1H1)
C      END

```

SUBROUTINE ELEMN1 (APPLE-II PLUS)

```

C...!.*..1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!...
$USES UCOLHT IN DEVEL:COLHT.CODE OVERLAY
$USES URUSS1 IN DEVEL:RUSS1.CODE OVERLAY
$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
$USES UTRUSS1 IN DEVEL:TRUSS1.CODE OVERLAY
C
C      SUBROUTINE ELEMN1
C      COMMON /EL/ IND,NPAR(3),NUMEG,MTOT,NDOF,NLCASE,NBRLOD,KTR
C      NPAR1 = NPAR( 1 )
C      GO TO ( 1, 2, 3 ), NPAR1
C
C      1 CALL TRUSS1
C      RETURN
C
C      2 RETURN
C
C      3 RETURN
C
C      END

```

$$C \dots ! \cdot 1+0 \dots ! \dots 2+0 \dots ! \dots 3+0 \dots ! \dots 4+0 \dots ! \dots 5+0 \dots ! \dots 6+0 \dots ! \dots 7+0 \dots ! \dots$$

\$USES UCOLHT IN DEVEL:COLHT.CODE OVERLAY

\$USES URUSS1 IN DEVEL:RUSS1.CODE OVERLAY

\$USES UERROR IN DEVEL:ERROR.CODE OVERLAY

U

SUBROUTINE TRUSS1

U

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

٤

```
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTDTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
COMMON /RWORK/ A(1)
COMMON /IWORK/ IA(1)
```

ۛ

EQUIVALENCE (NPAR(2), NUME), (NPAR(3), NUMMAT)

U

```

NI3 = NI2 + NEQ
NI4 = NI3 + NEQ + 1
NI5 = NI4 + 6 * NUNE
NI6 = NI5 + NUNE
NENDI = NI6

```

6

$$\begin{aligned} \text{NRS} &= \text{NR4} + \text{NUMAT} \\ \text{NRE} &= \text{NR5} + \text{NUMAT} \end{aligned}$$

SUBROUTINE TRUSS1 (APPLE-II VERSION)

```

C
      NR7 = NR6 + 6 * NUME
      NENDR = NR7

      IF( NR7 .GT. MTOTR ) CALL ERROR( NR7 - MTOTR, 3, 1 )
      IF( NI6 .GT. MTOTI ) CALL ERROR( NI6 - MTOTI, 3, 2 )

C
      MIDEST = 2 * NUMMAT + 2 * ( 6 * NUME ) + NUME + 1

C
      NNNN = NDOF

C
      CALL RUSS1(IA(NI1),A(NR1),A(NR2),A(NR3),A(NR1),IA(NI2),A(NR4),
1 A(NR5),IA(NI4),A(NR6),IA(NI5),NNNN)

C
      RETURN
C
      END

```


SUBROUTINE RUSS1 (APPLE-II PLUS)

C...!.*...1+0...!.2+0...!.3+0...!.4+0...!.5+0...!.6+0...!.7+0...!.8+0...!.9+0...!
\$USES UCOLHT IN DEVEL:COLHT.CODE OVERLAY

C
SUBROUTINE RUSS1(ID,X,Y,Z,U,MHT,E,AREA,LM,XYZ,MATP,NNNN)

C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C
CHARACTER*4 SPK(2), TALK

C
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /MDFRDM/ IDOF(6)
COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(1)
COMMON /IWORK/ IA(1)

C
DIMENSION X(1),Y(1),Z(1),ID(NNNN,1),E(1),AREA(1),LM(6,1),
1 XYZ(6,1),MATP(1),U(1),MHT(1)

C
EQUIVALENCE (NPAR(1),NPAR1),(NPAR(2),NUME),(NPAR(3),NUMMAT)

C
ND = 6

C
300 IPRINT = 5

IF(TALK.EQ.SPK(1)) WRITE(IOUT,2000) NPAR1,NUME

SUBROUTINE RUSS1 (APPLE-II PLUS)

```

IF(TALK.EQ.SPK(2)) WRITE(IOUT,2001) NPAR1, NUME
IF(NUMMAT.EQ.0) NUMMAT = 1
IF(TALK.EQ.SPK(1)) WRITE(IOUT,2010) NUMMAT
IF(TALK.EQ.SPK(2)) WRITE(IOUT,2011) NUMMAT
IF(TALK.EQ.SPK(1)) WRITE(IOUT,2020)
IF(TALK.EQ.SPK(2)) WRITE(IOUT,2021)

```

C

```

DO 10 I = 1, NUMMAT
READ(IIN,1000) N,E(N), AREA(N)
10 WRITE(IOUT,2030) N,E(N), AREA(N)

```

C

```

N = 1
100 READ(IIN,1020) M, II, JJ, MTYP, KG

```

C

```

IF(KG.EQ.0) KG = 1
120 IF(M.NE.N) GO TO 200
I = II
J = JJ
MTYPE = MTYP
KKK = KG

```

C

```

200 XYZ(1,N)=X(I)
XYZ(2,N)=Y(I)
XYZ(3,N)=Z(I)
XYZ(4,N)=X(J)
XYZ(5,N)=Y(J)
XYZ(6,N)=Z(J)

```

C

SUBROUTINE RUSS1 (APPLE-II PLUS)

```

C      MATP(N)=MTYPE
      DO 390 L = 1,6
390    LM(L,N) = 0
C
      DO 400 L = 1,3
      IF(IDOF(L).EQ.1) GO TO 400
      LM(L,N)=ID(L,I)
      LM(L+3,N)=ID(L,J)
400    CONTINUE
C
      CALL COLHT(MHT,ND,LM(1,N))
C
      IPRINT = IPRINT + 1
C
      IF( (IPRINT .LE. 55) .AND. (IPRINT .NE. 6) ) GO TO 401
C
      IF(TALK.EQ.SPK(1)) WRITE(IOUT,2040)
      IF(TALK.EQ.SPK(2)) WRITE(IOUT,2041)
      IPRINT = 6
C
401    WRITE(IOUT,2050) N,I,J,MTYPE
C
      IF(N.EQ.NUME) RETURN
      N = N + 1
      I = I + KKK
      J = J + KKK
      IF(N.GT.M) GO TO 100

```

SUBROUTINE RUSS1 (APPLE-II PLUS)

PAGE: 4

GO TO 120

C

DO 6 I = N2,N5-1
6 IA(I) = 0

C

1000 FORMAT(15,2F10.0)

1020 FORMAT(5I5)

2000 FORMAT(/,48H DEF INITION DES ELEMENTS : ,//,

1 16H TYPE D'ELEMENT,13(2H.),17H(NPAR(1)) . . =,15/,
2 34H EQ.1 FIEMENT DE FERME SIMPLE/,
3 34H EQ.2 ELEMENTS NON DISPONIBLE/,
4 30H EQ.3 DANS CETTE VERSION /,
5 20H NOMBRE D'ELEMENTS .,11(2H.),17H(NPAR(2)) . . =,15//)

2001 FORMAT(/,36H ELEMENT DEF INITION ///,

1 14H ELEMENT TYPE ,13(2H.),17H(NPAR(1)) . . =,15/,
2 25H EQ.1 TRUSS ELEMENTS/,30H EQ.2 UNAVAILABLE ELEMENT/,
3 30H EQ.3 UNAVAILABLE ELEMENT/,
4 20H NUMBER OF ELEMENTS.,10(2H.),17H(NPAR(2)) . . =,15//)

2010 FORMAT(/,50H DEF INITION DES MATERIAUX : ,//

1 33H NOMBRE DE GROUPE DE MATERIAUX ET
2 /32H DE SECTION DROITE (AIRES)
3 5(2H.),17H(NPAR(3)) . . =,15//)

2011 FORMAT(/,42H MATERIALE DEF INITION ///,

1 37H NUMBER OF DIFFERENT SETS OF MATERIAL
2 /32H AND CROSS SECTIONAL CONSTANTS ,
3 4(2H.),17H(NPAR(3)) . . =,15//)

2020 FORMAT(/,2X,6HNUMERO,4X,6HMODULE,6X,14HSECTION DROITE/

1 1X,9HDE GROUPE,2X,7HD' YOUNG,10X,4HAIRE,/15X,1HE,14X,1HA)

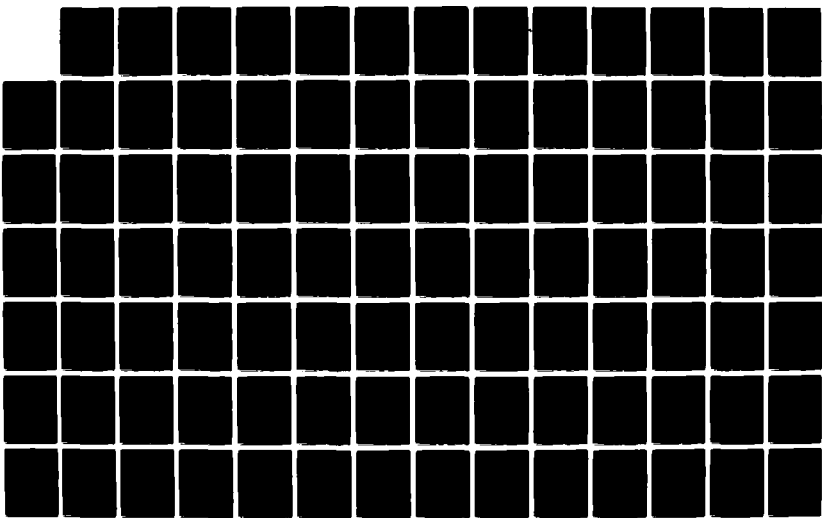
AD-A125 629

AN INVESTIGATION OF THE FEASIBILITY OF IMPLEMENTING
SUBSTANTIAL FINITE ELEMENT CODES ON POPULAR
MICROCOMPUTERS(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA
D J MULHOLLAND OCT 82 F/G 9/2

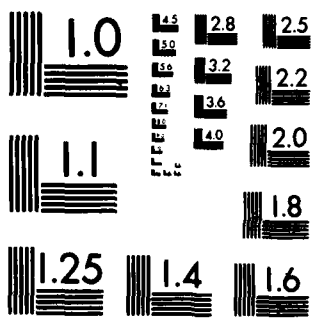
3/3

UNCLASSIFIED

NL



M-2



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUBROUTINE RUSS1 (APPLE-II PLUS)

```

2021 FORMAT(///2X,3HSET,7X,6HYOUNGS,6X,15HCROSS-SECTIONAL/
      1 1X,6HNUMBER,5X,7HMODULUS,10X,4HAREA,715X,1HE,14X,1HA)
2030 FORMAT(15,4X,E12.6,2X,E14.6)
2040 FORMAT(40H1 I N F O R M A T I O N   S U R   L E S ,
      1 18H E L E M E N T S : ,///
      2 8H ELEMENT ,5X,4HNODE,5X,4HNODE,7X,8HMATERIAL/,
      3 9H NOMBRE-N,6X,1H1,8X,1HJ,4X,16HNUMERO DE GROUPE/)
2041 FORMAT(1H1,40H E L E M E N T   I N F O R M A T I O N   ///,
      1 8H ELEMENT ,5X,4HNODE,7X,8HMATERIAL/,
      2 9H NUMBER-N,6X,1H1,8X,1HJ,7X,10HSET NUMBER/)
2050 FORMAT(15,6X,15,4X,15,7X,15)

```

C

END

[illegible]

SUBROUTINE COLHT (MHT, ND, LM)

```
IMPLICIT REAL (A-H,O-Z), INTEGER (I-N)
```

DIMENSION LM(ND), MHT(1)

57 = 32000

DO 300 I = 1, ND

IF(LM(I)) 100, 300, 100

100	IF(LM(I) - LS)	200,	300,
-----	------------------	------	------

200 LS = LM(I)

300 CONTINUE

DO 400 I = 1, ND

$$II = LM(I)$$

IF(II.EQ.0) GO TO 400

ME - II - LS

```
IF (ME.GT. MHT(II)) MHT(II)=ME
```

400 CONTINUE

RETURN

END

PROGRAM LOAD (APPLE-II PLUS)

PAGE: 1

```

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!....
$USES URWCOMN IN DEVEL:RWCOMN.CODE OVERLAY
$USES ULADS IN DEVEL:LOADS.CODE OVERLAY
$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
C
PROGRAM LOAD
C
IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)
C
CHARACTER*23 FNAME1,FNAME2
CHARACTER*4 SPK(2),TALK,BLOCK,LABEL
CHARACTER*1 ANSWER,AFFIRM
C
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEG,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK
COMMON /FREQIF/ ISTOH,ISTOTE
COMMON /MDFRDM/ IDOF(6)
COMMON /VAR/ NG,MODEX
COMMON /LONGER/ LONG
COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(2000)
COMMON /IWORK/ IA(2000)
C

```

```

PROGRAM LOAD (APPLE-II PLUS)

      EQUIVALENCE ( NPAR(2), NUME ), ( NPAR(3), NUMMAT )

      DATA AFFIRM/'Y' /

      WRITE(*,'(A)') 'LOADS VERSION 2.0  23 MAR 82'
      WRITE(*,'(A)') 'ENTER (DISK):(FILENAME).TEXT !!!'
      READ(*,'(A)') FNAME1
      WRITE(*,'(A)') '(CONSOLE:$) OR (PRINTER:$) OUTPUT ???'
      READ(*,'(A)') FNAME2

      ICOM = 7
      BLOCK = 'LOAD'

      WRITE(*,'(A)') '----> OPENING FILES !!!'

      OPEN(2,FILE='#11:LOAD',ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='UNFORMATTED')
      OPEN(5,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='FORMATTED')
      OPEN(6,FILE=FNAME2,ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='FORMATTED')
      OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')

      WRITE(*,'(A)') '----> READING COMMON VARIABLES AND THE'
      WRITE(*,'(A)') 'ENTIRE WORKSPACE FROM DATABASE !!!'
      CALL RWCOMN( 1 )

```

PROGRAM LOAD (APPLE-II PLUS)

```

WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
READ(*,'(A)') ANSWER
IF( ANSWER .EQ. AFFIRM ) GO TO 777

C
WRITE(*,'(A)') 'DIAGNOSTICS:'
C
WRITE(*,'(A)') 'ID ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)
C
WRITE(*,'(A)') 'MHT ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)
C
WRITE(*,'(A)') 'MAXA ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)
C
WRITE(*,'(A)') 'LM ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)
C
WRITE(*,'(A)') 'MATP ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)
C
WRITE(*,'(A)') 'E ARRAY:'
WRITE(*,9898) (I,A(I),I=NR4,NR5-1)
C
WRITE(*,'(A)') 'AREA ARRAY:'
WRITE(*,9898) (I,A(I),I=NR5,NR6-1)
C
WRITE(*,'(A)') 'XYZ ARRAY:'

```

PROGRAM LOAD (APPLE-II PLUS)

```

C      WRITE(*,9898) (I,A(I),I=NR6, NR7-1)
C
C      777 NEND = NR1 + 2 * NUMMAT + 6 * NUME
C
C      DO 10 I = NR1, NEND
C      10 A(I) = A(I+NR4-NR1)
C
C      NR2 = NR1 + NUMMAT
C      NR3 = NR2 + NUMMAT
C      NR4 = NR3 + 6 * NUME
C      NR5 = NR4 + NEQ
C
C      IF(TALK .EQ. SPK(1)) WRITE( IOUT, 2010 )
C      IF(TALK .EQ. SPK(2)) WRITE( IOUT, 2011 )
C
C      REWIND IIN
C      REWIND ILOAD
C
C      999 READ(IIN,1001,END=888) LABEL
C      IF(LABEL .NE. BLOCK) GO TO 999
C
C      DO 300 L = 1, NLCASE
C
C      READ( IIN, 1010 ) LL, NLOAD
C
C      IF(TALK .EQ. SPK(1)) WRITE( IOUT, 2020 ) LL, NLOAD
C      IF(TALK .EQ. SPK(2)) WRITE( IOUT, 2021 ) LL, NLOAD
C      IF( LL .EQ. L ) GO TO 250

```

PROGRAM LOAD (APPLE-II PLUS)

```

IF(TALK .EQ. SPK(1)) WRITE( IOUT, 3000 )
IF(TALK .EQ. SPK(2)) WRITE( IOUT, 3001 )
STOP
250 CONTINUE
C
NI7 = NI6 + NLOAD
NI8 = NI7 + NLOAD
NENDI = NI8
C
NR6 = NR5 + NLOAD
NENDR = NR6
C
IF ( NR6 .GT. MTOTR ) CALL ERROR( NR6 - MTOTR, 3, 1 )
IF ( NI8 .GT. MTOTI ) CALL ERROR( NI8 - MTOTI, 3, 2 )
C
CALL LOADS(A(NR4), IA(NI6), IA(NI7), A(NR5), IA(NI1), NLOAD, NDOF, NEQ)
C
300 CONTINUE
C
CLOSE(2, STATUS='KEEP')
CLOSE(5, STATUS='KEEP')
CLOSE(6)
C
CLOSE(7, STATUS='DELETE')
C
OPEN(7, FILE='#12:ICOM', ACCESS='SEQUENTIAL', STATUS='NEW',
1 FORM='UNFORMATTED')
WRITE(*, '(A)') '----' WRITING COMMON VARIABLES AND THE'

```

PROGRAM LOAD (APPLE-II PLUS)

```

WRITE(*,'(A)') ' ENTIRE WORKSPACE INTO DATABASE :!'
CALL RWCOMN( 2 )

CLOSE(7,STATUS='KEEP')

WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
READ(*,'(A)') ANSWER
IF( ANSWER.EQ. AFFIRM ) GO TO 555

WRITE(*,'(A)') 'DIAGNOSTICS:'

WRITE(*,'(A)') 'ID ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)

WRITE(*,'(A)') 'MHT ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)

WRITE(*,'(A)') 'MAXA ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)

WRITE(*,'(A)') 'LM ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)

WRITE(*,'(A)') 'MATP ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)

WRITE(*,'(A)') 'NOD ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI6,NI7-1)

```

PROGRAM LOAD (APPLE-II PLUS)

```

C      WRITE(*,'(A)') 'IDIRN ARRAY:'
      WRITE(*,9898) (I,IA(I),I=NI7,NI8-1)

C      WRITE(*,'(A)') 'E ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)

C      WRITE(*,'(A)') 'AREA ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)

C      WRITE(*,'(A)') 'XYZ ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)

C      WRITE(*,'(A)') 'R ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR4,NR5-1)

C      WRITE(*,'(A)') 'FLOAD ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR5,NR6-1)

C      555 STOP

C      888 IF(TALK .EQ. SPK(1)) WRITE(IOUT,1002) BLOCK
      IF(TALK .EQ. SPK(2)) WRITE(IOUT,1012) BLOCK
      STOP

C      1001 FORMAT(1A4)
      1002 FORMAT(/,' ERROR: ',1A4,' INPUT DATA BLOCK NOT FOUND !!!',/)
      1012 FORMAT(/,' ERROR: ',1A4,' INPUT DATA BLOCK NOT FOUND !!!',/)

```

PROGRAM LOAD (APPLE-II PLUS)

PAGE: 8

```
1010 FORMAT( 215 )
2010 FORMAT('1' CHARGEMENTS DONNES')
2011 FORMAT('1' LOADING INFORMATION')
2020 FORMAT(/,/, 'CAS DE CHARGEMENT NUMERO. . . . .', 15,/,
A      ' , NOMBRE DE CHARGES CONCENTREES . . . . .', 15,/,
2021 FORMAT(/,/, ' LOADING CASE NUMBER . . . . .', 15,/,
A      ' , NUMBER OF CONCENTRATED LOADS. . . . .', 15,/,
3000 FORMAT(' *** ERREUR: CAS DE CHARGEMENT SANS ORDRE !!!')
3001 FORMAT(' *** ERROR: LOADING CASE OUT OF ORDER !!!')
8989 FORMAT('IA(', 115,')=' , 116)
9898 FORMAT('A(', 115,')=' , 1E15.6)
```

C

END

SUBROUTINE LOADS (APPLE-II PLUS)

```

C...!.*.1+0...!.2+0...!.3+0...!.4+0...!.5+0...!.6+0...!.7+0...!.
SUBROUTINE LOADS( R, NOD, IDIRN, FLOAD, ID, NLOAD, NDOF, NEQ )
C
C IMPLICIT REAL( A-H, O-Z ), INTEGER( I-N )
C
C CHARACTER*4 SPK(2), TALK
C
C COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM
C COMMON /MDFRDM/ IDOF(6)
C COMMON /VAR/ NG, MODEX
C COMMON /SPEAK/ SPK, TALK
C
C DIMENSION R(NEQ), NOD(NLOAD), IDIRN(NLOAD), FLOAD(NLOAD),
1 ID(NDOF,1)
C DATA ZE / 0.E0 /
C
C IF(TALK .EQ. SPK(1))WRITE( IOUT, 2000 )
C IF(TALK .EQ. SPK(2)) WRITE( IOUT, 2001 )
C READ( IIN, 1000 ) ( NOD(I), IDIRN(I), FLOAD(I), I = 1, NLOAD )
C
C WRITE( IOUT, 2010 ) ( NOD(I), IDIRN(I), FLOAD(I), I = 1, NLOAD )
C
C IF( MODEX .EQ. 0 ) RETURN
C
C DO 210 I = 1, NEQ
C 210 R( I ) = ZE
C
C DO 220 L = 1, NLOAD

```

SUBROUTINE LOADS (APPLE-II PLUS)

```

LN = NOD(L)
LI = IDIRN( L )
LM = LI
DO 230 I = 1, LI
230 LM = LM - IDOF( I )
II = ID( LM, LN )
C
IF( II ) 220, 250, 240
C
240 R( II ) = R( II ) + FLOAD( L )
C
220 CONTINUE
C
WRITE( ILOAD ) (R(K),K = 1, NEO)
C
RETURN
C
250 IF(TALK.EQ. SPK(1)) WRITE( IOUT, 3000 ) LI, LN
IF(TALK.EQ. SPK(2)) WRITE( IOUT, 3001 ) LI, LN
STOP
C
1000 FORMAT( 2I5, F10.0 )
2000 FORMAT( 31H NOEUD D. L. CHARGE ,/,
1 31H NUMERO VALEUR )
2001 FORMAT( 31H NODE D.O.F. LOAD ,/,
1 31H NUMBER NUMBER VALUE )
2010 FORMAT( 1X, I5, 6X, I1, 7X, 1E13.6 )
3000 FORMAT( ' D. L. NUMERO ', 12, ' DU NOEUD ', 15, ' EST IMPOSE !! ' )

```

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SUBROUTINE LOADS (APPLE-II PLUS)

3001 FORMAT(' DOF NUMBER ',I2,' OF NODE ',I5,' IS IMPOSED !! ')

C

END

$$C: \dots * 1+0 \dots ! \dots 2+0 \dots ! \dots 3+0 \dots ! \dots 4+0 \dots ! \dots 5+0 \dots ! \dots 6+0 \dots ! \dots 7+0 \dots ! \dots$$

*****USES URWCOMN IN DEVEL:RWCOMN.CODE OVERLAY**

USES USBLOCK IN DEVEL:SBLOCK, CODE OVERLAY

USES ERROR IN DEVEL:ERROR.CODE OVERLAY

W

PROGRAM BLOCKS

U

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

U

CHARACTER*1 ANSWER, AFFIRM

CHARACTER*4 SPK(2), TALK

CHARACTER*23 FNAME1

U

```

COMMON /REALPT/ NR1, NR2, NR3, NR4, NR5, NR6, NR7, NR8, NENDR
COMMON /INTPT/ NI1, NI2, NI3, NI4, NI5, NI6, NI7, NI8, NENDI
COMMON /SOL/ NUMNP, NEG, NWK, NWM, NWC, NUMEST, MIDEST, MAXEST, MA
COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM
COMMON /EL/ IND, NPAR(3), NUMEG, MTOTR, MTOTI, NDOF, NLCASE, NBRLOD, KTR
COMMON /FLGLTH/ NFIRST, NLAST, NBCEL

```

COMMON /ADDB/ MBLOCK, NEQ1, NEQL, NEQR, MLA, NBLOCK

COMMON /FREQIF/ ISTOH, ISTOTE

COMMON	/MDFRDM/	IDOF(6)
COMMON	/MDFRDM/	IDOF(6)

COMMON /VAR/ NG, MODEX

COMMON / LONGER / LONG

COMMON /SPEAK/ SPK; TR

COMMON /BOWK/ 0(2000)

COMMON /WORK/ 1A(2000)
COMMON /WORK/ 1A(2000)

RESEARCH / ANALYSIS

2

PROGRAM BLOCKS (APPLE-II PLUS)

```

C      EQUIVALENCE ( NPAR(2), NUME )
C
C      DATA AFFIRM/'Y'/
C
C      WRITE(*,'(A)') 'BLOCKS VERSION 2.0  24 MAR 82'
C      WRITE(*,'(A)') ' (CONSOLE:$) OR (PRINTER:$) OUTPUT !!!'
C      READ(*,'(A)') FNAME1
C
C      ICOM = 7
C
C      WRITE(*,'(A)') '----> OPENING FILES !!!'
C
C      OPEN(6,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='NEW',
C      1 FORM='FORMATTED')
C      OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='OLD',
C      1 FORM='UNFORMATTED')
C
C      WRITE(*,'(A)') '----> READING FROM DATABASE ALL COMMON'
C      WRITE(*,'(A)') '      VARIABLES AND ENTIRE WORKSPACE !!!'
C      CALL RWCOMM(1)
C
C      WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
C      READ(*,'(A)') ANSWER
C      IF(ANSWER .EQ. AFFIRM) GO TO 888
C
C      WRITE(*,'(A)') 'DIAGNOSTICS:'
C
C      WRITE(*,'(A)') 'ID ARRAY:'

```

PROGRAM BLOCKS (APPLE-II PLUS)

```

C      WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)
      WRITE(*,'(A)') 'MHT ARRAY:'
      WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)
C
      WRITE(*,'(A)') 'MAXA ARRAY:'
      WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)
C
      WRITE(*,'(A)') 'LM ARRAY:'
      WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)
C
      WRITE(*,'(A)') 'MATP ARRAY:'
      WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)
C
      WRITE(*,'(A)') 'E ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)
C
      WRITE(*,'(A)') 'AREA ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)
C
      WRITE(*,'(A)') 'XYZ ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)
C      888 CONTINUE
C
      NEND = NI1 + NEQ + (NEQ+1) + 6 * NUME + NUME
C      DO 350 I = NI1,NEND

```

PROGRAM BLOCKS (APPLE-II PLUS)

```

350 IA( I ) = IA( I + NI2 - NI1 )
C
MSTORE = NEQ1 + 3 * NEQ + MAXEST + NBCEL
C
NI2 = NI1 + NEQ
NI3 = NI2 + NEQ + 1
NI4 = NI3 + 6 * NUME
NI5 = NI4 + NUME
NI6 = NI5 + NEQ
NI7 = NI6 + NEQ
C
IF( NI7 .GT. MTOTI ) CALL ERROR( NI7 - MTOTI, 4, 2 )
C
IBLOCK = 4
NBLOCK = 1
C
400 MELST = IBLOCK * 2
ISTORL = ( MTOT - MSTORE - MELST )
IF( ISTOTE .GT. 0 ) ISTORL = ISTOTE
C
CALL SBLOCK( IA(NI2), IA(NI5), IA(NI6), ISTORL, NBLOCK, NEQ, NWK, ISTOH )
C
IF( ISTOTE .GT. 0 ) GO TO 450
C
IF( NBLOCK .LE. IBLOCK ) GO TO 450
C
IBLOCK = IBLOCK * 2
C

```

PROGRAM BLOCKS (APPLE-II PLUS)

```

IF( IBLOCK .LT. MBLOCK ) GO TO 400
IF(TALK.EQ.SP(1)) WRITE( IOUT, 3010 ) MBLOCK
IF(TALK.EQ.SP(2)) WRITE( IOUT, 3011 ) MBLOCK
STOP
C
450 MAM = NWK / NEQ + 1
IF(TALK.EQ.SP(1)) WRITE( IOUT, 2030 ) NEQ, NWK, MA, MAM, ISTOH, NBLOCK
IF(TALK.EQ.SP(2)) WRITE( IOUT, 2031 ) NEQ, NWK, MA, MAM, ISTOH, NBLOCK
C
IF(TALK.EQ.SP(1)) WRITE( IOUT, 2040 )
IF(TALK.EQ.SP(2)) WRITE( IOUT, 2041 )
C
NN = N15 + NBLOCK - 1
IF(TALK.EQ.SP(1)) WRITE( IOUT, 2050 ) (I, I = 1, NBLOCK )
IF(TALK.EQ.SP(2)) WRITE( IOUT, 2051 ) (I, I = 1, NBLOCK )
C
IF(TALK.EQ.SP(1)) WRITE( IOUT, 2060 ) ( IAC I ), I = N15, NN )
IF(TALK.EQ.SP(2)) WRITE( IOUT, 2061 ) ( IAC I ), I = N15, NN )
C
NN = N16 + NBLOCK - 1
IF(TALK.EQ.SP(1)) WRITE( IOUT, 2070 ) ( IAC I ), I = N16, NN )
IF(TALK.EQ.SP(2)) WRITE( IOUT, 2071 ) ( IAC I ), I = N16, NN )
C
NN = N15 + NBLOCK
C
DO 500 I = 1, NBLOCK
500 IAC( NN + I - 1 ) = IAC ( N16 + I - 1 )
C

```


PROGRAM BLOCKS (APPLE-II PLUS)

```

C
  NI6 = NN
  NI7 = NI6 + NBLOCK
  NENDI = NI7

  CLOSE(7, STATUS='DELETE')
  OPEN(7, FILE='12:ICOM', ACCESS='SEQUENTIAL', STATUS='NEW',
    1 FORM='UNFORMATTED')

C
  WRITE(*, '(A)') '----> WRITING INTO DATABASE ALL COMMON'
  WRITE(*, '(A)') '  VARIABLES AND ENTIRE WORKSPACE !!!'
  CALL RWCOMM(2)

C
  CLOSE(7, STATUS='KEEP')
  CLOSE(6)

C
  WRITE(*, '(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
  READ(*, '(A)') ANSWER
  IF(ANSWER .EQ. AFFIRM) GO TO 999

C
  WRITE(*, '(A)') 'DIAGNOSTICS:'

C
  WRITE(*, '(A)') 'MHT ARRAY:'
  WRITE(*, 8989) (I, IA(I), I=NI1, NI2-1)

C
  WRITE(*, '(A)') 'MAXA ARRAY:'
  WRITE(*, 8989) (I, IA(I), I=NI2, NI3-1)

C
  WRITE(*, '(A)') 'LM ARRAY:'

```

PROGRAM BLOCKS (APPLE-II PLUS)

```

C      WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)

C      WRITE(*,'(A)') 'MATP ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)

C      WRITE(*,'(A)') 'NCOLBV ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)

C      WRITE(*,'(A)') 'ICOPL ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI6,NI7-1)

C      WRITE(*,'(A)') 'E ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)

C      WRITE(*,'(A)') 'AREA ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)

C      WRITE(*,'(A)') 'XYZ ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)

C      999 STOP

C      2030 FORMAT(47H1 CARACTERISTIQUES DU SYSTEME D'EQUATIONS:
A      47H- NOMBRE D'EQUATIONS . . . . . (NEQ) =,17,/,
B      47H0 NOMBRE D'ELEMENTS DE LA MATRICE . . . (NWK) =,17,/,
C      47H0 DEMI LARGEUR MAXIMALE DE LA BANDE . . (MA) =,17,/,
D      47H0 DEMI LARGEUR CONSIDERE DE LA BANDE . (MAM) =,17,/,

```

```

E      47H0 NOMBRE DE TERMES PAR BLOC . . . . . (ISTOH)=,17,/,
F      47H0 NOMBRE DE BLOCS DE SOLUTION . . . . . (NBLOC)=,17 )
2031 FORMAT(47H1 CHARACTERISTICS OF THE SYSTEM OF EQUATIONS:
A      47H- NUMBER OF EQUATIONS . . . . . (NEQ) =,17,/,
B      47H0 NUMBER OF COEFFICIENTS IN THE MATRIX (NWK) =,17,/,
C      47H0 MAXIMUM HALF-BANDWIDTH . . . . . (MA) =,17,/,
D      47H0 AVERAGE HALF-BANDWIDTH . . . . . (MAM) =,17,/,
E      47H0 NUMBER OF COEFFICIENTS PER BLOCK . . . . . (ISTOH)=,17,/,
F      47H0 NUMBER OF BLOCKS FOR THE SOLUTION . . (NBLOC)=,17 )
2040 FORMAT(53H- NOMBRE DE COLONNES PAR BLOC ET 1ER BLOC COUPLE
2041 FORMAT(53H- NUMBER OF COLUMNS PER BLOC AND 1ST COUPLED BLOCK
2050 FORMAT(/31H0 NUMEROS DES BLOCS:
2051 FORMAT(/31H0 BLOCK NUMBERS:
2060 FORMAT(/32H0 NOMBRES DE COLONNES DES BLOCS:
2061 FORMAT(/32H0 NUMBER OF COLUMNS PER BLOCK:
2070 FORMAT(/31H0 PREMIERS BLOCS COUPLES:
2071 FORMAT(/31H0 FIRST COUPLED BLOCK:
3010 FORMAT('*** ERROR: NOMBRE DE BLOCS PLUS GRAND QUE MBLOCK =',15)
3011 FORMAT('IA(',115,')='',116)
8989 FORMAT('A(',115,')='',1E15.6)
9898 FORMAT('A(',115,')='',1E15.6)

```

END

C

SUBROUTINE SBLOCK (APPLE-II PLUS)

C...!. *.1+0...!. 2+0...!. 3+0...!. 4+0...!. 5+0...!. 6+0...!. 7+0...!.

SUBROUTINE SBLOCK(MAXA,NCOLBV,ICOPL,ISTORL,NBLOCK,NEQ,NWK,ISTOH)

C IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C CHARACTER*4 SPK(2), TALK

C COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM
C COMMON /SPEAK/ SPK, TALK

C INTEGER MAXA(1), NCOLBV (1), ICOPL (1)

C IF(NBLOCK .GT. 1) GO TO 5

C IF(NWK .GT. ISTORL) GO TO 5

C NBLOCK = 1

C NCOLBV(1) = NEQ

C ICOPL(1) = 1

C ISTOH = NWK

C RETURN

C 5 ISTOH = ISTORL / 2

C ISTORL = ISTOH * 2

C DO 10 I = 1, NEQ

C ICL = MAXA(I + 1) - MAXA(1)

C IF(ISTOH .GE. ICL) GO TO 10

C IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2000) I

C IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2001) I

C STOP

SUBROUTINE SBLOCK (APPLE-II PLUS)

```

C
10 CONTINUE
C
NBLOCK = 0
NN = 0
IB = 0
C
DO 100 I = 2, NEQ
140 II = ISTOH - MAXA( I + 1 ) + 1 + NN
IF( II ) 120, 100, 100
C
120 NN = MAXA( I ) - 1
NBLOCK = NBLOCK + 1
NCOLBV( NBLOCK ) = I - 1 - IB
IB = I - 1
GO TO 140
C
100 CONTINUE
NBLOCK = NBLOCK + 1
NCOLBV( NBLOCK ) = NEQ - IB
C
DO 50 I = 1, NBLOCK
50 ICOPL( I ) = I
C
IF( NBLOCK .EQ. 1 ) RETURN
C
NN = NCOLBV( 1 )
DO 200 N = 2, NBLOCK

```

SUBROUTINE SBLOCK (APPLE-II PLUS)

```

ICLM = 0
NCOLB = NCOLBV( N )
C
DO 110 I = 1, NCOLB
ICL = MAXA( NN + I + 1 ) - MAXA( NN + I ) - I - 1
IF( ICL .GT. ICLM ) ICLM = ICL
C
110 CONTINUE
C
J = N - 1
150 IF( ICLM .LE. 0 ) GO TO 180
ICOLP( N ) = J
ICLM = ICLM - NCOLBV( J )
J = J - 1
GO TO 150
C
180 NN = NN + NCOLBV( N )
200 CONTINUE
C
RETURN
C
2000 FORMAT( '*** ERREUR: MEMOIRE CENTRALE PETITE POUR LA COLONNE ', I5 )
2001 FORMAT( '*** ERROR: NOT ENOUGH MEMORY FOR COLUMN ', I5 )
C
END

```

216

PROGRAM ASEMBL (APPLE-II PLUS)

COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(2000)
COMMON /IWORK/ IA(2000)

C

DATA AFFIRM/'Y' /

C

ICOM = 7

C

WRITE(*,'(A)') 'ASSEMBLE VERSION 2.0 26 MAR 82'
WRITE(*,'(A)') '(CONSOLE:*) OR (PRINTER:*) ERROR MSGS. ???'
READ(*,'(A)') FNAME1

C

WRITE(*,'(A)') '---> OPENING SEQUENTIAL FILES !!!'

C

OPEN(1,FILE='#11:IELMNT',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')
OPEN(6,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='FORMATTED')
OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')

C

WRITE(*,'(A)') '---> READING FROM DATABASE ALL COMMON'
WRITE(*,'(A)') ' VARIABLES AND ENTIRE WORKSPACE !!!'

C

CALL RWCOMN(1)

C

WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
READ(*,'(A)') ANSWER

PROGRAM ASEMBL (APPLE-II PLUS)

```

C      IF(ANSWER .EQ. AFFIRM) GO TO 777
C
C      WRITE(*,'(A)') 'DIAGNOSTICS:'
C
C      WRITE(*,'(A)') 'MHT ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)
C
C      WRITE(*,'(A)') 'MAXA ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)
C
C      WRITE(*,'(A)') 'LM ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)
C
C      WRITE(*,'(A)') 'MATP ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)
C
C      WRITE(*,'(A)') 'NCOLBV ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)
C
C      WRITE(*,'(A)') 'ICOPL ARRAY:'
C      WRITE(*,8989) (I,IA(I),I=NI6,NI7-1)
C
C      WRITE(*,'(A)') 'E ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)
C
C      WRITE(*,'(A)') 'AREA ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)

```

```

PROGRAM ASEMBL (APPLE-II PLUS)

      WRITE(*,'(A)') 'XYZ ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)

C
      WRITE(*,'(A)') 'R ARRAY:'
      WRITE(*,9898) (I,A(I),I=NR4,NR5-1)

C
      777 IF( MODEX .EQ. 0 ) GO TO 444

C
      WRITE(*,'(A)') '---> OPENING DIRECT ACCESS FILE !!!'

C
      OPEN(4,FILE='#12:IRIG',ACCESS='DIRECT',STATUS='NEW',
        1 FORM='UNFORMATTED',RECL=LONG)

C
      444 NR2 = NR1 + 1STOH

C
      NEND = NI3 + 2 * NBLOCK

C
      DO 350 I = NI3, NEND
        350 IA(I) = IA( I + NI5 - NI3 )

C
        NI4 = NI3 + NBLOCK
        NI5 = NI4 + NBLOCK

C
        IF( MODEX .NE. 0 ) GO TO 550
        GO TO 650

C
      550 CONTINUE
      IND = 2

```

PROGRAM ASEMBL (APPLE-II PLUS)

```

C      NBCEL = 0
      CALL ASSEM( IA(NI2), A(NR1), IA(NI3), ISTOH )
C
C      NBRLOD = 0
      KTR = 1
C
C      650 CLOSE(7,STATUS='DELETE')
C
      OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='UNFORMATTED')
C
      WRITE(*,'(A)') '----' WRITING INTO DATABASE ALL COMMON'
      WRITE(*,'(A)') '    VARIABLES AND ENTIRE WORKSPACE !!!'
C
      CALL RWCOMN( 2 )
C
      WRITE(*,'(A)') '----' CLOSING ALL FILES !!!'
C
      CLOSE(1,STATUS='KEEP')
      IF( MODEX .NE. 0 ) CLOSE(4,STATUS='KEEP')
      CLOSE(6)
      CLOSE(7,STATUS='KEEP')
C
      WRITE(*,'(A)') 'SKIP DIAGNOSTICS ??? (Y/N)'
      READ(*,'(A)') ANSWER
      IF(ANSWER .EQ. AFFIRM) GO TO 999
C
      WRITE(*,'(A)') 'DIAGNOSTICS:'

```

PROGRAM ASEMBL (APPLE-II PLUS)

```
C
WRITE(*,'(A)') 'MHT ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)

C
WRITE(*,'(A)') 'MAXA ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)

C
WRITE(*,'(A)') 'NCOLBY ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)

C
WRITE(*,'(A)') 'ICDPL ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)

C
WRITE(*,'(A)') 'LM ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)

C
WRITE(*,'(A)') 'MATP ARRAY:'
WRITE(*,8989) (I,IA(I),I=NI6,NI7-1)

C
WRITE(*,'(A)') 'AA ARRAY:'
WRITE(*,9898) (I,A(I),I=NR1,NR2-1)

C
WRITE(*,'(A)') 'E ARRAY:'
WRITE(*,9898) (I,A(I),I=NR2,NR3-1)

C
WRITE(*,'(A)') 'AREA ARRAY:'
WRITE(*,9898) (I,A(I),I=NR3,NR4-1)

C
```

PROGRAM ASEMBL (APPLE-II PLUS)

WRITE(*,'(A)') 'XYZ ARRAY:'
WRITE(*,9898) (I,A(I),I=NR4,NR5-1)

C 999 STOP

C 8989 FORMAT('IA(',115,')= ',116)
9898 FORMAT('A(',115,')= ',1E15.6)

C END

SUBROUTINE ASSEM (APPLE-II PLUS)

C...1.*.1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!.....

\$USES URADBAN IN DEVEL:ADDBAN.CODE OVERLAY
\$USES URUSS2 IN DEVEL:RUSS2.CODE OVERLAY
\$USES UERRR IN DEVEL:ERROR.CODE OVERLAY
\$USES UTRUSS2 IN DEVEL:TRUSS2.CODE OVERLAY
\$USES UELMN2 IN DEVEL:ELEMN2.CODE OVERLAY

C
SUBROUTINE ASSEM(MAXA, AA, NCOLBV, ISTOH)
IMPLICIT REAL (A-H,O-Z), INTEGER(I-N)

C
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK
COMMON /LONGER/ LONG
COMMON /RWORK/ A(1)
COMMON /IWORK/ IA(1)

C
INTEGER MAXA(1), NCOLBV(1)

C
DIMENSION AA(ISTOH)

C
DATA ZE / 0.E0 /

C
NEQL = 1
NEQR = 0
MLA = 0

SUBROUTINE ASSEM (APPLE-II PLUS)

```

C
      IADR = 1
      INAD = ( ISTOH + LONG - 1 ) / LONG

      DO 300 L = 1, NBLOCK
      NEQR = NEQR + NCOLBV( L )
      DO 100 I = 1, ISTOH
      100 AA( I ) = ZE
C
      REWIND IELMNT
C
      DO 200 N = 1, NUMEG
      NG = N
C
      WRITE(*,'(A)') '--> READING ELEMNT INFORMATION '
      WRITE(*,'(1A29,1I3)') '    FOR ELEMNT GROUP NUMBER: ',N
C
      READ( IELMNT ) NUMEST, (NPAR(I), I=1,3)
C
      CALL ELEMN2
C
      200 CONTINUE
C
      WRITE(*,8989) L
      WRITE( IRIG,REC=IADR ) ( AA(ICOUNT), ICOUNT = 1, ISTOH )
      IADR = IADR + INAD
      NEQL = NEQL + NCOLBV( L )
      MLA = MAXA( NEQL ) - 1

```

PAGE: 3

SUBROUTINE ASSEM (APPLE-II PLUS)

300 CONTINUE

C

RETURN

C

8989 FORMAT('WRITING STIFFNESS RECORD --) ',113)

C

END

SUBROUTINE ELEMN2 (APPLE-II PLUS)

```

C...!.*1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!...
$USES UADDBAN IN DEVEL:ADDBAN.CODE OVERLAY
$USES URUSS2 IN DEVEL:RUSS2.CODE OVERLAY
$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
$USES UTRUSS2 IN DEVEL:TRUSS2.CODE OVERLAY
C
SUBROUTINE ELEMN2
C
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
C
NPAR1 = NPAR( 1 )
C
GO TO ( 1, 2, 3 ), NPAR1
C
1 CALL TRUSS2
  RETURN
C
2 RETURN
C
3 RETURN
C
END

```

SUBROUTINE TRUSS2 (APPLE-II PLUS)

```

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!....
$USES UADDBAN IN DEVEL:ADDBAN.CODE OVERLAY
$USES URUSS2 IN DEVEL:RUSS2.CODE OVERLAY
$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
C
SUBROUTINE TRUSS2
C
IMPLICIT REAL (A-H,O-Z), INTEGER (I-N)
C
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /RWORK/ A(1)
COMMON /IWORK/ IA(1)
C
EQUIVALENCE (NPAR(2),NUME), (NPAR(3),NUMMAT)
C
NR3 = NR2 + NUMMAT
NR4 = NR3 + NUMMAT
NR5 = NR4 + 6 * NUME
NENDR = NR5
C
NI6 = NI5 + 6 * NUME
NI7 = NI6 + NUME
NENDI = NI7
C
IF (NR5 .GT. MTOTR) CALL ERROR (NR5-MTOTR,4,1)

```

SUBROUTINE TRUSS2 (APPLE-II PLUS)

PAGE: 2

```
C      IF(NI7 .GT. MTOTI) CALL ERROR(NI7-MTOTI,4,2)
C      READ(1ELMNT) (A(I),I=NR2,NR5-1),(IA(I),I=NI5,NI7-1)
C      CALL RUSS2(IA(NI1),A(NR2),A(NR3),IA(NI5),A(NR4),IA(NI6))
C      RETURN
C      END
```

SUBROUTINE RUSS2 (APPLE-II PLUS)

C...1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!...
 \$USES UADDBAN IN DEVEL:ADDBAN.CODE OVERLAY

C
 SUBROUTINE RUSS2(MHT,E,AREA,LM,XYZ,MATP)

C
 IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C
 COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
 COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
 COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
 COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
 COMMON /RWORK/ A(1)
 COMMON /IWORK/ IA(1)

C
 DIMENSION E(1),AREA(1),LM(6,1),XYZ(6,1),MATP(1),MHT(1),S(21),
 1 ST(6),D(3)

C
 EQUIVALENCE (NPAR(2),NUME)

C
 ND = 6

C
 610 DO 500 N = 1,NUME
 MTYPE = MATP(N)
 XL2=0.

DO 505 L = 1,3
 D(L) = XYZ(L,N)-XYZ(L+3,N)
 505 XL2=XL2+D(L)*D(L)
 XL=SQRT(XL2)

```

SUBROUTINE RUSS2 (APPLE-II PLUS)
  XX=E(MTYPE)*AREA(MTYPE)*XL
  DO 510 L= 1,3
    ST(L) = D(L)/XL2
  510 ST(L+3) = -ST(L)
  C
    KL=0
    DO 600 L = 1,6
      YY = ST(L)*XX
    DO 600 K = L,6
      KL=KL+1
      S(KL)=ST(K)*YY
    600 CONTINUE
    CALL ADDBAN( A(NR1), IA(NI2), S, LM(1,N), ND )
    500 CONTINUE
  C
    RETURN
  C
    END

```

SUBROUTINE ADDBAN (APPLE-II PLUS)

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!......

C SUBROUTINE ADDBAN(A, MAXA, S, LM, ND)

C IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

C DIMENSION A(1), S(1),MAXA(1),LM(1)

C COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK

C NDI = 0

C DO 400 I = 1, ND

II = LM(I)

IF(II.LT. NEQL) .OR. (II.GT. NEQR)) GO TO 400

MI = MAXA(II) - MLA

KS = I

C DO 300 J = 1, ND

JJ = LM(J)

IF(JJ) 300, 300, 100

100 IJ = II - JJ

C IF(IJ) 300, 200, 200

200 KK = MI + IJ

KSS = KS

IF(J.GE. I) KSS = J + NDI

PAGE: 2

SUBROUTINE ADDBAN (APPLE-II PLUS)

 A(KK) = A(KK) + S(KSS)

300 KS = KS + ND - J

C

400 NDI = NDI + ND - I

C

 RETURN

C

 END

$$[\dots, 1+0, \dots, 2+0, \dots, 3+0, \dots, 4+0, \dots, 5+0, \dots, 6+0, \dots, 7+0, \dots]$$

\$USES URWCOMN IN DEVEL: RWCOMN. CODE OVERLAY

USES UCOL SOL IN DEVEL: CODE OVERLAY

USERS WILL ONLY IN NEVER :! ONLY CODE OVERLAY

USES UCLADV IN DEVEL:CODE OVERLAY
USES UERROR IN DEVEL:ERROR CODE OVERLAY

GREENE DEVELOPMENT PROGRAMS

U

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

U

CHARACTER*1 ANSWER, AFFIRM

CHARACTER*4 SPK(2), TALK

CHARACTER*23 FNAME1

U

```
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NROF,NLCASE,NBRLOD,KTR
```

COMMON /FLGTH/ NFIRST, NLAST, NBCEL

COMMON /ADDB/ MBLOCK, NEQ1, NEQL, NEQR, M1A, NBLOCK

COMMON /FREQIF/ ISTOH, ISTOIE

COMMON /MDFRDM/ IDOF(5)

COMMON /VAR/ NG-MODEX

COMMON /VAX/ NO, MODEX
COMMON /LONGER/ LONG

COMMON / LONGER / LONG
COMMON / SEVER / SPK TO

COMMON / SPEAK / SPAK, IALK
COMMON / SPEAK / SPAK, IALK
COMMON / SPEAK / SPAK, IALK

COMMON /RWORK/ A(2000)

COMMON /IWORK/ IA(2000)

U


```

PROGRAM SOLVE (APPLE-II PLUS)

      EQUIVALENCE ( NPAR(2), NUME )

      DATA AFFIRM/'Y'/

      ICOM = 7

      WRITE(*,'(A)') 'SOLVE VERSION 2.0  25 APRIL 82'
      WRITE(*,'(A)') '(CONSOLE:$) OR (PRINTER:$) ERROR MSGS. ?'
      READ(*,'(A)') FNAME1

      WRITE(*,'(A)') '----> OPENING SEQUENTIAL FILES !!!'

      OPEN(1,FILE='#11:IELMNT',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')
      OPEN(2,FILE='#11:ILoad',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')
      OPEN(3,FILE='#11:IDTAP',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')
      OPEN(6,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='FORMATTED')
      OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')

      CALL RWCOMN( 1 )

      IF(MODEX.EQ.0) THEN
      WRITE(*,'(A)') '----> UNABLE TO RUN SOLVE !!!'
      WRITE(*,'(A)') ' ( MODEX EQUAL TO ZERO)'

```

PROGRAM SOLVE (APPLE-II PLUS)

```

CLOSE(1,STATUS='KEEP')
CLOSE(2,STATUS='KEEP')
CLOSE(3,STATUS='KEEP')
CLOSE(6)
CLOSE(7,STATUS='KEEP')
GO TO 999
ENDIF

```

C

```

IF( KTR .GT. 1 ) THEN

```

C

```

WRITE(*,'(A)') 'SKIP ENTRY DIAGNOSTICS ??? (Y/N)'
READ(*,'(A)') ANSWER
IF(ANSWER .EQ. AFFIRM) GO TO 444

```

C

```

WRITE(*,'(A)') 'MULTIPLE LOADCASE DIAGNOSTICS:'

```

C

```

WRITE(*,'(A)') 'MAXA ARRAY:'
WRITE(*,8989) (1,IA(I),I=NI1,NI2-1)

```

C

```

WRITE(*,'(A)') 'NCOLBV ARRAY:'
WRITE(*,8989) (1,IA(I),I=NI2,NI3-1)

```

C

```

WRITE(*,'(A)') 'ICOPL ARRAY:'
WRITE(*,8989) (1,IA(I),I=NI3,NI4-1)

```

C

```

WRITE(*,'(A)') 'ID ARRAY:'
WRITE(*,8989) (1,IA(I),I=NI4,NI5-1)

```

C

PROGRAM SOLVE (APPLE-II PLUS)

```
C      WRITE(*,'(A)') 'LM ARRAY:'  
      WRITE(*,9898) (I,IA(I),I=NI5,NI6-1)  
  
C      WRITE(*,'(A)') 'MATP ARRAY:'  
      WRITE(*,9898) (I,IA(I),I=NI6,NI7-1)  
  
C      WRITE(*,'(A)') 'A ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)  
  
C      WRITE(*,'(A)') 'B ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)  
  
C      WRITE(*,'(A)') 'D ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)  
  
C      WRITE(*,'(A)') 'V ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR4,NR5-1)  
  
C      WRITE(*,'(A)') 'E ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR5,NR6-1)  
  
C      WRITE(*,'(A)') 'AREA ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR6,NR7-1)  
  
C      WRITE(*,'(A)') 'XYZ ARRAY:'  
      WRITE(*,9898) (I,A(I),I=NR7,NR8-1)  
  
      ENDIF
```

PROGRAM SOLVE (APPLE-II PLUS)

```

C 444 IF( KTR .GT. 1 ) GO TO 777
C
  WRITE(*,'(A)') 'SKIP ENTRY DIAGNOSTICS ??? (Y/N)'
  READ(*,'(A)') ANSWER
  IF(ANSWER .EQ. AFFIRM) GO TO 333
C
  WRITE(*,'(A)') 'FIRST LOADCASE DIAGNOSTICS:'
C
  WRITE(*,'(A)') 'MHT ARRAY:'
  WRITE(*,8989) (I,IA(I),I=NI1,NI2-1)
C
  WRITE(*,'(A)') 'MAXA ARRAY:'
  WRITE(*,8989) (I,IA(I),I=NI2,NI3-1)
C
  WRITE(*,'(A)') 'NCOLBV ARRAY:'
  WRITE(*,8989) (I,IA(I),I=NI3,NI4-1)
C
  WRITE(*,'(A)') 'ICOPL ARRAY:'
  WRITE(*,8989) (I,IA(I),I=NI4,NI5-1)
C
  WRITE(*,'(A)') 'LM ARRAY:'
  WRITE(*,8989) (I,IA(I),I=NI5,NI6-1)
C
  WRITE(*,'(A)') 'MATP ARRAY:'
  WRITE(*,8989) (I,IA(I),I=NI6,NI7-1)
C
  WRITE(*,'(A)') 'AA ARRAY:'

```

PROGRAM SOLVE (APPLE-II PLUS)

```

C      WRITE(*,9898) (I,A(I),I=NR1,NR2-1)
C      WRITE(*,'(A)') 'E ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR2,NR3-1)
C      WRITE(*,'(A)') 'AREA ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR3,NR4-1)
C      WRITE(*,'(A)') 'XYZ ARRAY:'
C      WRITE(*,9898) (I,A(I),I=NR4,NR5-1)
C      333 NEND = NI1 + (NEQ+1) + 2 * NBLOCK
C      DO 555 I = NI1,NEND
C      555 IA(I) = IA( I + NI2 - NI1 )
C      NI2 = NI1 + (NEQ+1)
C      NI3 = NI2 + NBLOCK
C      NI4 = NI3 + NBLOCK
C      NI5 = NI4 + NDOF * NUMNP
C      NENDI = NI5
C      NR2 = NR1 + ISTOH
C      NR3 = NR2 + ISTOH
C      NR4 = NR3 + NEQ
C      NR5 = NR4 + NEQ
C      NENDR = NR5

```

PROGRAM SOLVE (APPLE-II PLUS)

PAGE: 7

```

C      IF( NRS .GT. MTOTR ) CALL ERROR( NRS - MTOTR, 5, 1 )
C      IF( NIS .GT. MTOTI ) CALL ERROR( NIS - MTOTI, 5, 2 )

C      777 WRITE(*,'(A)') '----> OPENING DIRECT ACCESS FILES !!!'
C
C      OPEN(4,FILE='12:IRIG',ACCESS='DIRECT',STATUS='OLD',
C      1 RECL=LONG,FORM='UNFORMATTED')
C
C      IF( KTR .GT. 1 ) GO TO 888
C
C      CALL COLSQL( IA(NI1), IA(NI2), IA(NI3), A(NR1), A(NR2), A(NR3),
C      1 A(NR4), NEQ, NBLOCK, ISTOH, IRIG, KTR )
C
C      REWIND IDTAP
C      NN = NIS - 1
C      READ( IDTAP ) ( IA( I ), I = NI4, NN )
C
C      KTR = 2
C      IND = 3
C
C      888 NBRLOD = NBRLOD + 1
C
C      IF( NBRLOD .GT. NLCASE ) THEN
C      IF( TALK .EQ. SPK(1) ) WRITE (IOUT, 3000)
C      IF( TALK .EQ. SPK(2) ) WRITE (IOUT, 3001)
C      CLOSE(1,STATUS='KEEP')
C      CLOSE(2,STATUS='KEEP')
C      CLOSE(3,STATUS='KEEP')

```

PROGRAM SOLVE (APPLE-II PLUS)

CLOSE(4,STATUS='KEEP')
 CLOSE(6)
 CLOSE(7,STATUS='KEEP')
 GO TO 999
 ENDIF

REWIND ILOAD

DO 123 I = 1, NBRLOD
 123 CALL LOADV(A(NR4), NEQ)

CALL COLSOL(IA(NI1), IA(NI2), IA(NI3), A(NR1), A(NR2), A(NR3),
 1 A(NR4), NEQ, NBLOCK, ISTOH, IRIG, KTR)

CLOSE(1,STATUS='KEEP')
 CLOSE(2,STATUS='KEEP')
 CLOSE(3,STATUS='KEEP')
 CLOSE(4,STATUS='KEEP')
 CLOSE(6)
 CLOSE(7,STATUS='DELETE')
 OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='NEW',
 1 FORM='UNFORMATTED')

CALL RWCOMN(2)

CLOSE(7,STATUS='KEEP')

WRITE(*,'(A)') 'SKIP EXITING DIAGNOSTICS ??? (Y/N)'

PROGRAM SOLVE (APPLE-II PLUS)

```

C      READ(*,'(A)') ANSWER
      IF(ANSWER.EQ. AFFIRM) GO TO 999

C      WRITE(*,'(A)') 'EXIT CONDITION DIAGNOSTICS:'

C      WRITE(*,'(A)') 'MAXA ARRAY:'
      WRITE(*,8989) (I, IA(I), I=NI1, NI2-1)

C      WRITE(*,'(A)') 'NCOLBV ARRAY:'
      WRITE(*,8989) (I, IA(I), I=NI2, NI3-1)

C      WRITE(*,'(A)') 'ICOPL ARRAY:'
      WRITE(*,8989) (I, IA(I), I=NI3, NI4-1)

C      WRITE(*,'(A)') 'ID ARRAY:'
      WRITE(*,8989) (I, IA(I), I=NI4, NI5-1)

C      WRITE(*,'(A)') 'A ARRAY:'
      WRITE(*,9898) (I, A(I), I=NR1, NR2-1)

C      WRITE(*,'(A)') 'B ARRAY:'
      WRITE(*,9898) (I, A(I), I=NR2, NR3-1)

C      WRITE(*,'(A)') 'D ARRAY:'
      WRITE(*,9898) (I, A(I), I=NR3, NR4-1)

C      WRITE(*,'(A)') 'V ARRAY:'
      WRITE(*,9898) (I, A(I), I=NR4, NR5-1)

```


SUBROUTINE SOLVE (APPLE-II PLUS)

```

C      READ(*,'(A)') ANSWER
      IF(ANSWER.EQ. AFFIRM) GO TO 999

C      WRITE(*,'(A)') 'EXIT CONDITION DIAGNOSTICS:'

C      WRITE(*,'(A)') 'MAXA ARRAY:'
      WRITE(*,9989) (I,IA(I),I=NI1,NI2-1)

C      WRITE(*,'(A)') 'NCOLBV ARRAY:'
      WRITE(*,9989) (I,IA(I),I=NI2,NI3-1)

C      WRITE(*,'(A)') 'ICOPL ARRAY:'
      WRITE(*,9989) (I,IA(I),I=NI3,NI4-1)

C      WRITE(*,'(A)') 'ID ARRAY:'
      WRITE(*,9989) (I,IA(I),I=NI4,NI5-1)

C      WRITE(*,'(A)') 'A ARRAY:'
      WRITE(*,9998) (I,A(I),I=NR1,NR2-1)

C      WRITE(*,'(A)') 'B ARRAY:'
      WRITE(*,9998) (I,A(I),I=NR2,NR3-1)

C      WRITE(*,'(A)') 'D ARRAY:'
      WRITE(*,9998) (I,A(I),I=NR3,NR4-1)

C      WRITE(*,'(A)') 'V ARRAY:'
      WRITE(*,9998) (I,A(I),I=NR4,NR5-1)

```

PROGRAM SOLVE (APPLE-II PLUS)

```

C
C 999 STOP
C
8989 FORMAT('IA',115,')= ',116)
9898 FORMAT('A',115,')= ',1E15.6)
3000 FORMAT( 44H- UNABLE TO RUN SOLVE. NO MORE LOADCASES !!! )
3001 FORMAT( 44H- UNABLE TO RUN SOLVE. NO MORE LOADCASES !!! )
C
END

```

SUBROUTINE COLSOL (APPLE-II PLUS)

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!....
C

 SUBROUTINE COLSOL(MAXA, NCOLBV, ICOPL, A, B, D, V, NEG, NBLOCK,
 1 ISTORL, NSTIF, NRED, KKK)

C
 IMPLICIT REAL(A-H, O-Z), INTEGER(I-N)

C
 CHARACTER*4 SPK(2), TALK

C
 COMMON /LONGER/ LONG

C
 COMMON /SPEAK/ SPK, TALK

C
 COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IIRIG, IIN, IOUT, ICOM

C
 INTEGER ICOPL(1), NCOLBV(1), MAXA(1)

C
 DIMENSION A(ISTORL), B(ISTORL), D(NEG), V(1)

C
 DATA KLIN, IDTHF / 0, 0 /

C
 DATA ZE, GRAND / 0.E0, 1.E+20 /

C
 KHBB = 0

C
 IADR = 1

C
 INAD = (ISTORL + LONG - 1) / LONG

C
 IF(KKK - 2) 10, 610, 610

10 NRED = NSTIF

 PIVOT = GRAND

C

SUBROUTINE COLSOL (APPLE-II PLUS)

```

C      DO 600 NJ = 1, NBLOCK
      READ( NSTIF, REC=IADR ) ( A(ICOUNT), ICOUNT = 1, ISTORL )
      NCOLB = NCOLBV( NJ )
      MM = MAXA( KHBB + 1 ) - 1
      IF( NJ .EQ. ICOPL( NJ ) ) GO TO 300

C      IK = ICOPL( NJ ) - 1
      IM = 0
      IF( IK ) 300, 140, 100

C      100 DO 120 K = 1, IK
      120 IM = IM + NCOLBV( K )

C      140 KHB = KHBB - IM
      IADR = IK * INAD + 1
      IK = IK + 1
      NJ1 = NJ - 1

C      DO 160 NK = IK, NJ1
      READ( NRED, REC=IADR ) ( B(ICOUNT), ICOUNT = 1, ISTORL )
      IADR = IADR + INAD
      KHB = KHB - NCOLBV( NK )
      MC = MAXA( IM + 1 ) - 1

C      DO 200 N = 1, NCOLB
      KN = MAXA( KHBB + N ) - MM
      KL = KN + 1

```

SUBROUTINE COLSOL (APPLE-II PLUS)

```

KU = MAXA( KHBB + N + 1 ) - 1 - MM
KH = KU - KL - N + 1
KC = KH - KHB
IF( KC .LE. 0 ) GO TO 200
IC = 0
KCL = NCOLBV( NK ) - KC + 1
IF( KCL .GT. 0 ) GO TO 210
IC = 1 - KCL
KCL = 1
210 KCR = NCOLBV( NK )
KLT = KU - IC
C
DO 220 K = KCL, KCR
IC = IC + 1
KLT = KLT - 1
KI = MAXA( K + IM ) - MC
ND = MAXA( K + IM + 1 ) - KI - MC - 1
IF( ND ) 220, 220, 230
230 KK = MIN0( IC, ND )
C = ZE
C
DO 240 L = 1, KK
240 C = C + B(KI+L) * A(KLT+L)
A(KLT) = A(KLT) - C
220 CONTINUE
C
200 CONTINUE
C

```

SUBROUTINE COLSOL (APPLE-II PLUS)

```

C      IM = IM + NCOLBV( NK )
C      160 CONTINUE
C      300 DO 400 N = 1, NCOLB
          KN = MAXA( KHBB + N ) - MM
          KL = KN + 1
          KU = MAXA( KHBB + N + 1 ) - 1 - MM
          KDIF = KU - KL
          KH = MIN0( KDIF, N-1 )
          KS = N + KHBB
          IF( KH ) 420, 440, 460
          460 K = N - KH
              KLT = KL + KH
              IC = 0
              IF( (N-1) .LT. KDIF ) IC = KDIF - N + 1
C
          DO 480 J = 1, KH
              IC = IC + 1
              KLT = KLT - 1
              KI = MAXA( KHBB + K ) - MM
              ND = MAXA( KHBB + K + 1 ) - KI - MM - 1
              IF( ND ) 480, 480, 500
              500 KK = MIN0( IC, ND )
                  C = ZE
C
          DO 520 L = 1, KK
              520 C = C + A( KI + L ) * A( KLT + L )

```

SUBROUTINE COLSOL (APPLE-II PLUS)

```

C      A(KLT) = A(KLT) - C
480 K = K + 1
C
C      440 K = KS
C
C      E = ZE
C
C      DO 540 KK = KL, KU
C      K = K - 1
C
C      C = A( KK ) / D( K )
C      E = E + C * A( KK )
540 A( KK ) = C
C
C      A( KN ) = A( KN ) - E
C
C      420 D( KS ) = A( KN )
C      IF( D(KS) ) 560, 555, 400
555 IF( IDTHF.EQ. 0 ) GO TO 560
C      D( KS ) = PIVOT
C      GO TO 400
C
C      560 IF(TALK.EQ.SPK(1)) WRITE( IOUT, 2000 ) KS, D( KS )
C      IF(TALK.EQ.SPK(2)) WRITE( IOUT, 2001 ) KS, D( KS )
C      STOP
C      400 CONTINUE

```

SUBROUTINE COLSOL (APPLE-II PLUS)

```

C      KHBB = KHBB + NCOLB
      WRITE( NSTIF, REC=IADR ) ( A(ICOUNT), ICOUNT = 1, IstorL )
      IADR = IADR + INAD
600 CONTINUE
      IF( KLIN .GT. 0 ) GO TO 605
      RETURN
C
605 KHBB = 0
      IADR = 1
C
610 NRED = NSTIF
      DO 700 NJ = 1, NBLOCK
          IF( (NBLOCK.EQ.1) .AND. ( (KLIN.EQ.0) .OR. (KKK.EQ.1) ) ) GO TO
              1 710
          READ( NRED, REC=IADR ) ( A(ICOUNT), ICOUNT = 1, IstorL )
          IADR = IADR + INAD
          NCOLB = NCOLBV( NJ )
          MM = MAXA( KHBB + 1 ) - 1
C
          DO 720 N = 1, NCOLB
              KL = MAXA( N + KHBB ) - MM + 1
              KU = MAXA( N + KHBB + 1 ) - MM - 1
              IF( KU - KL ) 720, 730, 730
          730 KS = N + KHBB
              K = KS
              C = ZE
C

```


SUBROUTINE COLSOL (APPLE-II PLUS)

```

      DO 740 KK = KL, KU
      K = K - 1
      740 C = C + A( KK ) * V( K )
      C
      V( KS ) = V( KS ) - C
      720 CONTINUE
      C
      KHBB = KHBB + NCOLB
      700 CONTINUE
      C
      DO 790 N = 1, NEQ
      C
      790 V( N ) = V( N ) / D( N )
      C
      NBL = NBLOCK
      C
      DO 800 NJ = 1, NBLOCK
      IF( NBLOCK .EQ. 1 ) GO TO 820
      C
      IADR = IADR - INAD
      READ( NRED, REC=IADR ) ( A( ICOUNT ), ICOUNT = 1, ISTORL )
      C
      NCOLB = NCOLBV( NBL )
      820 KHBB = KHBB - NCOLB
      MM = MAXA( KHBB + 1 ) - 1
      N = NCOLB
      C
      DO 860 L = 1, NCOLB

```

SUBROUTINE COLSOL (APPLE-II PLUS)

KL = MAXA(N + KHBB) - MM + 1
 KU = MAXA(N + KHBB + 1) - MM - 1

IF(KU - KL) 861, 890, 890

890 KS = KHBB + N

K = KS

DO 900 KK = KL, KU

K = K - 1

900 V(K) = V(K) - A(KK) * V(KS)

861 N = N - 1

860 CONTINUE

NBL = NBL - 1

800 CONTINUE

RETURN

2000 FORMAT(' ARRET - MATRICE N ETANT PAS DEFINIE POSITIVE', /,
 1, ' LE PIVOT DE L EQUATION ', I4, /, ' PIVOT = ', E20.14)
 2001 FORMAT(' STOP - STIFFNESS MATRIX IS NOT POSITIVE DEFINITE', /,
 1, ' THE PIVOT OF EQUATION ', I4, /, ' IS ---> ', E20.14)

END

PAGE: 1

SUBROUTINE LOADV (APPLE-II PLUS)

C...!.*.1+0...!.2+0...!.3+0...!.4+0...!.5+0...!.6+0...!.7+0...!......

SUBROUTINE LOADV(R, NEQ)

C IMPLICIT REAL(A-H, O-Z), INTEGER(I-N)

C COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM

C DIMENSION R(NEQ)

C READ(ILOAD) (R(I), I = 1, NEQ)

C RETURN

C END

PROGRAM STRES (APPLE-II PLUS)

PAGE: 1

C...!.*.1+0...!.2+0...!.3+0...!.4+0...!.5+0...!.6+0...!.7+0...!......
C

\$USES URUSS3 IN DEVEL:RUSS3.CODE OVERLAY
\$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
\$USES UTRUSS3 IN DEVEL:TRUSS3.CODE OVERLAY
\$USES UELEMN3 IN DEVEL:ELEMN3.CODE OVERLAY
\$USES USTRESS IN DEVEL:STRESS.CODE OVERLAY
\$USES UWRITE IN DEVEL:WRITE.CODE OVERLAY
\$USES URWCOMN IN DEVEL:RWCOMN.CODE OVERLAY

C

PROGRAM STRES

C

IMPLICIT REAL(A-H, O-Z), INTEGER(I-N)

C

CHARACTER*1 ANSWER, AFFIRM
CHARACTER*4 SPK(2), TALK
CHARACTER*23 FNAME1

C

COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /SOL/ NUMNP,NEQ,NWK,NWM,NWC,NUMEST,MIDEST,MAXEST,MA
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
COMMON /ADDB/ MBLOCK,NEQ1,NEQL,NEQR,MLA,NBLOCK
COMMON /FREQIF/ ISTOH,ISTOTE
COMMON /MDFROM/ IDOF(6)
COMMON /VAR/ NG,MODEX

```

PROGRAM STRES (APPLE-II PLUS)

COMMON /LONGER/ LONG
COMMON /SPEAK/ SPK,TALK
COMMON /RWORK/ A(2000)
COMMON /IWORK/ IA(2000)

C
ICOM = 7
C

WRITE(*,'(A)') 'STRESSES VERSION 1.0 6 APRIL 82'
WRITE(*,'(A)') '(CONSOLE:$) OR (PRINTER:$) OUTPUT ???'
READ(*,'(A)') FNAME1
C

WRITE(*,'(A)') '---> OPENING SEQUENTIAL FILES !!!'
C

OPEN(1,FILE=' #11:IELMNT',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')
OPEN(6,FILE=FNAME1,ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='FORMATTED')
OPEN(7,FILE=' #12:ICOM',ACCESS='SEQUENTIAL',STATUS='OLD',
1 FORM='UNFORMATTED')
C

CALL RWCOMN( 1 )
C

IF(MODEX.EQ.0) THEN
WRITE(*,'(A)') '---> UNABLE TO RUN STRESSES !!!'
WRITE(*,'(A)') ' (MODEX EQUAL TO ZERO)'
CLOSE(1,STATUS='KEEP')
CLOSE(2,STATUS='KEEP')
CLOSE(3,STATUS='KEEP')

```

PROGRAM STRES (APPLE-II PLUS)

```

CLOSE(6)
CLOSE(7,STATUS='KEEP')
GO TO 999
ENDIF
C      CALL WRITE( A(NR4), IA(NI4), NEQ, NDOF, NUMNP, NBRLOD )
C
C      CALL STRESS
C
CLOSE(1,STATUS='KEEP')
CLOSE(2,STATUS='KEEP')
CLOSE(3,STATUS='KEEP')
CLOSE(4,STATUS='KEEP')
CLOSE(6)
CLOSE(7,STATUS='DELETE')
OPEN(7,FILE='#12:ICOM',ACCESS='SEQUENTIAL',STATUS='NEW',
1 FORM='UNFORMATTED')
C      CALL RWCOMN( 2 )
C
CLOSE(7,STATUS='KEEP')
C
999 STOP
C
END

```

SUBROUTINE WRITE (APPLE-II PLUS)

C.....*1+0.....2+0.....3+0.....4+0.....5+0.....6+0.....7+0.....!

SUBROUTINE WRITE(DISP, ID, NEQ, NDOF, NUMNP, NBRLOD)

C IMPLICIT REAL(A-H, O-Z), INTEGER(I-N)

C CHARACTER*4 SPK(2), TALK

C COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM

C COMMON /MDFRDM/ IDOF(6)

C COMMON /SPEAK/ SPK, TALK

C DIMENSION DISP(NEQ), ID(NDOF, 1), D(6)

C DATA ZE / 0.E0 /

C DO 800 JJ = 1, 2

C IC = 5

C DO 600 II = 1, NUMNP

C IC = IC + 1

C IF((IC .LT. 56) .AND. (IC .NE. 6)) GO TO 100

C IF(TALK.EQ.SPK(1)) WRITE(IOUT, 2080) NBRLOD

C IF(TALK.EQ.SPK(2)) WRITE(IOUT, 2081) NBRLOD

C IF((TALK.EQ.SPK(1)) .AND. (JJ.EQ. 1)) WRITE(IOUT, 1000)

C IF((TALK.EQ.SPK(2)) .AND. (JJ.EQ. 1)) WRITE(IOUT, 1001)

SUBROUTINE WRITE (APPLE-II PLUS)

```

IF( (TALK.EQ.SPK(1)) .AND. (JJ.EQ. 2) ) WRITE( IOUT, 2001 )
IF( (TALK.EQ.SPK(2)) .AND. (JJ.EQ. 2) ) WRITE( IOUT, 2002 )
IC = 6

```

```

C 100 DO 200 I = 1, 6
200 D( I ) = ZE
IL = 0
DO 500 I = 1, NDOF
KK = ID( I, II )
300 IL = IL + 1
IF( IL .LE. 6 ) GO TO 400
IF( TALK.EQ.SPK(1) ) WRITE( IOUT, 3000 )
IF( TALK.EQ.SPK(2) ) WRITE( IOUT, 3001 )
STOP

```

```

C 400 IF( IDOF( IL ) .EQ. 1 ) GO TO 300
500 IF( KK.NE. 0 ) D( IL ) = DISP( KK )
IF( JJ.EQ. 1 ) WRITE( IOUT, 2010 ) II, (D(I), I=1,3)
IF( JJ.EQ. 2 ) WRITE( IOUT, 2010 ) II, (D(I), I=4,6)
600 CONTINUE
800 CONTINUE

```

C

RETURN

```

C 1000 FORMAT(17H- DEPLACEMENTS: ,/, 21H NOEUD DEPLACEMENT-U,
A 7X, 34HDEPLACEMENT-V DEPLACEMENT-W )
1001 FORMAT(18H- DISPLACEMENTS: ,/, 22H NODE DISPLACEMENT-U,
A 6X, 35HDISPLACEMENT-V DISPLACEMENT-W )

```


SUBROUTINE WRITE (APPLE-II PLUS)

PAGE: 3

```
2001 FORMAT(14H- ROTATIONS:      ,/,21H NOEUD ROTATION-X ,  
A 7X,30HROTATION-Y      ROTATION-Z )  
2002 FORMAT(14H- ROTATIONS:      ,/,21H NODE ROTATION-X ,  
A 7X,30HROTATION-Y      ROTATION-Z )  
2010 FORMAT(16,2X,6(1PE13.6,7X))  
2080 FORMAT(37H1 C A S   D E   C H A R G E M E N T :      , 13//)  
2081 FORMAT(28H1 L O A D I N G   C A S E :      , 13//)  
3000 FORMAT(55H- *** ERREUR : DEGRE DE LIBERTE PAR NOEUD ETANT MAUVAIS )  
3001 FORMAT(50H- *** ERROR : WRONG NUMBER OF D. O. F.'S PER NODE )
```

C

END

SUBROUTINE STRESS (APPLE-II PLUS)

```

C...!.*.1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!....
$USES URUSS3 IN DEVEL:RUSS3.CODE OVERLAY
$USES UERRR IN DEVEL:ERROR.CODE OVERLAY
$USES UTRUSS3 IN DEVEL:TRUSS3.CODE OVERLAY
$USES UELEMN3 IN DEVEL:ELEMN3.CODE OVERLAY
C
C SUBROUTINE STRESS
COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IOUT,ICOM
COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
COMMON /VAR/ NG,MODEX
COMMON /RWORK/ A(1)
COMMON /IWORK/ IA(1)
C
C REWIND IELMNT
C
C DO 100 N = 1, NUMEG
C
C NG = N
C
C READ( IELMNT ) NUMEST,(NPAR(I),I=1,3)
C
C CALL ELEMN3
C
C 100 CONTINUE
C

```

PAGE: 2

SUBROUTINE STRESS (APPLE-II PLUS)

RETURN

C

END

SUBROUTINE ELEMN3 (APPLE-II PLUS)

```

C...!.*..1+0...!....2+0...!....3+0...!....4+0...!....5+0...!....6+0...!....7+0...!......
$USES URUSS3 IN DEVEL:RUSS3.CODE OVERLAY
$USES UERROR IN DEVEL:ERROR.CODE OVERLAY
$USES UTRUSS3 IN DEVEL:TRUSS3.CODE OVERLAY
C
C SUBROUTINE ELEMN3
C COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
C COMMON /FLGLTH/ NFIRST,NLAST,NBCEL
C NPAR1 = NPAR( 1 )
C GO TO ( 1, 2, 3 ), NPAR1
C
C 1 CALL TRUSS3
C RETURN
C 2 RETURN
C 3 RETURN
C END

```

SUBROUTINE TRUSS3 (APPLE-II PLUS)

C...1...1+0...1...2+0...1...3+0...1...4+0...1...5+0...1...6+0...1...7+0...1...
 \$USES URUSS3 IN DEVEL:RUSS3.CODE OVERLAY
 \$USES UERROR IN DEVEL:ERROR.CODE OVERLAY

SUBROUTINE TRUSS3

IMPLICIT REAL(A-H,O-Z), INTEGER(I-N)

COMMON /REALPT/ NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,NENDR
 COMMON /INTPT/ NI1,NI2,NI3,NI4,NI5,NI6,NI7,NI8,NENDI
 COMMON /TAPES/ IELMNT,ILOAD,IDTAP,IRIG,IIN,IDUT,ICOM
 COMMON /EL/ IND,NPAR(3),NUMEG,MTOTR,MTOTI,NDOF,NLCASE,NBRLOD,KTR
 COMMON /RWORK/ A(1)
 COMMON /IWORK/ IA(1)

EQUIVALENCE (NPAR(2),NUME), (NPAR(3),NUMMAT)

NNNN = NDOF

NR6 = NR5 + NUMMAT
 NR7 = NR6 + NUMMAT
 NR8 = NR7 + 6 * NUME
 NENDR = NR8

NI6 = NI5 + 6 * NUME
 NI7 = NI6 + NUME
 NENDI = NI7

SUBROUTINE TRUSS3 (APPLE-II PLUS)

IF(NR8 .GT. MTOTR) CALL ERROR(NRS-MTOTR, 5, 1)
 IF(NI7 .GT. MTOTI) CALL ERROR(NI7-MTOTI, 5, 2)

C

READ(IELMNT) (A(I), I=NRS, NR8-1), (IA(I), I=NI5, NI7-1)

C

CALL RUSS3(A(NR4), A(NR5), A(NR6), IA(NI5), A(NR7), IA(NI6), NNNN)

C

RETURN

C

END

C...!...1+0...!...2+0...!...3+0...!...4+0...!...5+0...!...6+0...!...7+0...!
 C

SUBROUTINE RUSS3(U, E, AREA, LM, XYZ, MATP, NNNN)

IMPLICIT REAL (A-H,O-Z), INTEGER (I-N)

CHARACTER*4 SPK(2), TALK

```
COMMON /TAPES/ IELMNT, ILOAD, IDTAP, IRIG, IIN, IOUT, ICOM
COMMON /EL/ IND, NPAR(3), NUMEG, MTOTR, MTOTI, NDOF, NLCASE, NBRLOD, KTR
COMMON /VAR/ NG, MODEX
COMMON /SPEAK/ SPK, TALK
```

```

DIMENSION U(1),E(1),AREA(1),LM(6,1),XYZ(6,1),MATP(1)
DIMENSION ST(6),D(3)

```

EQUIVALENCE (NPAR(2), NUME)

```
IPRINT = 5
```

DO 830 N = 1, NUNE

```
IPRINT = IPRINT + 1
```

```
IF( IPRINT .LE. 55) .AND. ( IPRINT .NE. 6) ) GO TO 901
```

```
IF(TALK .EQ. SPK(1)) WRITE(IOUT,2050) NG
IF(TALK .EQ. SPK(2)) WRITE(IOUT,2061) NG
```

SUBROUTINE RUSS3 (APPLE-II PLUS)

```
C
C      IPRINT = 6
C
C      901 MTYPE = MATP(N)
C      XL2 = 0.0
C
C      DO 820 L = 1,3
C      D(L) = XYZ(L,N) - XYZ(L+3,N)
C      820 XL2 = XL2 + D(L) * D(L)
C
C      DO 814 L = 1,3
C      ST(L) = (D(L)/XL2)*E(MTYPE)
C      814 ST(L+3) = - ST(L)
C
C      STR = 0.0
C
C      DO 806 L = 1,3
C      I = LM(L,N)
C      IF(I .LE. 0) GO TO 807
C
C      STR = STR + ST(L) * U(I)
C      807 J = LM(L+3,N)
C      IF(J .LE. 0) GO TO 806
C
C      STR = STR + ST(L+3)*U(J)
C      806 CONTINUE
C
C      P = STR * AREA(MTYPE)
```


SUBROUTINE RUSS3 (APPLE-II PLUS)

```

C
C   WRITE(IOUT,2070) N,P,STR
C
C   830 CONTINUE
C
C   RETURN
C
C   2060 FORMAT(48H1 CALCULS DES CONTRAINTES,
C             1 48H POUR LE GROUP D' ELEMENT ,I4//,
C             2 2X,7HELEMENT,12X,SHFORCE,12X,6HSTRESS,/,2X,6HNOMBRE,/)
C   2061 FORMAT(48H1 STRES CALCULATIONS FOR,
C             1 27H ELEMENT GROUP,I4//,
C             2 2X,7HELEMENT,12X,SHFORCE,12X,6HSTRESS,/,2X,6HNUMBER,/)
C   2070 FORMAT(1X,115,11X,1E13.6,4X,1E13.6)
C
C   END

```

APPENDIX G

INPUT FILES FOR PROBLEMS USED IN TESTING STAP-NPS

PAGE: 1

SAMPLE 3-ELEMENT PLANE TRUSS

ENGL
TEST TRUSS NO. 1

3001111 1 1 1 128

10.0
15.0
10.0

0.0
0.0
5.0

0.0
0.0
0.0

0
0
0

ELEM

1 3 1
130000000. 0.5

0
0
0

LOAD

1 1 1
2 2 -1000.

SAMPLE MULTIPLE LOAD PLANE TRUSS

ENGL	TEST	TRUSS NO.	2	1	2	1	64	10.0	0.0	0.0	0
	4001111	1	1	1	1	1	1	10.0	0.0	0.0	0
	1	1	1	1	1	1	1	15.0	0.0	0.0	0
	2	0	1	1	1	1	1	17.5	4.330127	0.0	0
	3	0	0	1	1	1	1	12.5	4.330127	0.0	0
	4	0	0	1	1	1	1				
ELEM	1	5	1								
	130000000.	0.5									
	1	1	2	1	0						
	2	2	3	1	0						
	3	3	4	1	0						
	4	4	1	1	0						
	5	4	2	1	0						
LOAD	1	1									
	3	1	2000.								
	2	1									
	3	1	1000.								

SAMPLE MULTIPLE MATERIAL LARGE PLANE TRUSS

```

FRAN
TEST TRUSS NO. 3 (TESTS SUBSTANTIAL PROBLEM SIZE AND AUTO. NODE GEN.)
36001111 1 1 1 256
1 -1 -1 -1 -1 -1 -1 -10.0 0.0 0.0 1
3 -1 -1 -1 -1 -1 -1 -10.0 0.0 0.0 0
4 1 1 1 1 1 1 10.0 0.0 0.0 0
5 1 1 1 1 1 1 10.0 0.0 0.0 5
6 0 0 0 -1 -1 -1 -11.0 0.0 0.0 0
21 0 0 0 -1 -1 -1 -14.0 0.0 0.0 5
7 0 0 0 -1 -1 -1 -11.0 0.0 0.0 1
22 0 0 0 -1 -1 -1 -14.0 0.0 0.0 0
24 0 0 0 -1 -1 -1 -14.0 0.0 0.0 0
8 0 0 0 -1 -1 -1 -11.0 0.0 0.0 5
18 0 0 0 -1 -1 -1 -13.0 0.0 0.0 1
20 0 0 0 -1 -1 -1 -13.0 0.0 0.0 0
9 0 0 0 1 1 1 11.0 0.0 0.0 0
10 0 0 0 1 1 1 11.0 0.0 0.0 0
14 0 0 0 1 1 1 12.0 0.0 0.0 0
15 0 0 0 1 1 1 12.0 0.0 0.0 0
25 0 0 0 -1 -1 -1 -15.0 0.0 0.0 1
27 0 0 0 -1 -1 -1 -15.0 0.0 0.0 0
29 0 0 0 -1 -1 -1 -16.0 0.0 0.0 2
35 0 0 0 -1 -1 -1 -19.0 0.0 0.0 0
28 0 0 0 -1 -1 -1 -16.0 0.0 0.0 2
36 0 0 0 -1 -1 -1 -110.0 0.0 0.0 0
ELEM
1 72 2
1 200000. 0.00258

```

SAMPLE MULTIPLE MATERIAL LARGE PLANE TRUSS

2	200000.	0.00129	
1	1	6	2
2	2	6	2
3	2	7	2
4	3	7	2
5	3	8	2
6	6	7	2
7	7	8	2
8	6	11	2
9	7	11	2
10	7	12	2
11	8	12	2
12	8	13	2
13	11	12	2
14	12	13	2
15	11	16	2
16	12	16	2
17	12	17	2
18	13	17	2
19	13	18	2
20	16	17	2
21	17	18	2
22	16	21	2
23	17	21	2
24	17	22	2
25	18	22	2
26	18	19	2
27	18	23	2

SAMPLE MULTIPLE MATERIAL LARGE PLANE TRUSS

28	21	22	2
29	22	23	2
30	21	25	2
31	22	25	2
32	22	26	2
33	25	26	2
34	25	28	2
35	4	9	1
36	5	9	1
37	5	10	1
38	9	10	1
39	9	14	1
40	10	14	1
41	10	15	1
42	14	15	1
43	14	19	1
44	15	19	1
45	15	20	1
46	19	20	1
47	19	23	1
48	20	23	1
49	20	24	1
50	23	24	1
51	23	26	1
52	24	26	1
53	24	27	1
54	26	27	1
55	26	28	1

SAMPLE MULTIPLE MATERIAL LARGE PLANE TRUSS

56	27	28	1
57	27	29	1
58	28	29	1
59	28	30	1
60	29	30	1
61	29	31	1
62	30	31	1
63	30	32	1
64	31	32	1
65	31	33	1
66	32	33	1
67	32	34	1
68	33	34	1
69	33	35	1
70	34	35	1
71	34	36	1
72	35	36	1
LOAD	1	1	
	36	2	-0.1

ELEM	1	12	1	
	1100000000	00.28		
	1	1	2	1
	3	3	4	0
	4	4	1	0
	5	1	8	0
	6	2	5	1
	8	4	7	0
	9	8	4	0
	10	5	1	1
	12	7	3	1
				0

LOAD	1	12
	1	1 -10.0
	1	2-120.0
	1	3-105.0

PAGE: 2

SAMPLE SPACE TRUSS

2	1	-10.0
2	2	-100.0
2	3	-105.0
3	1	10.0
3	2	-100.0
3	3	-165.0
4	1	10.0
4	2	-120.0
4	3	-165.0

APPENDIX H

SAMPLE OUTPUT FROM STAP-NPS

PAGE: 1

PROGRAM ONE ENGLISH OUTPUT (SPACE TRUSS)

```

1 TEST SPACE TRUSS NO. 4 (TESTS 3-D CAPABILITY AND AUTO. ELEMENT GENER.)
  CONTROL PARAMETERS:
    NUMBER OF NODAL POINTS. . . . . (NUMNP) = 8
    NUMBER OF DEGREES OF FREEDOM PER NODE . . . . (NDOF) = 3
    NUMBER OF ELEMENT GROUPS. . . . . (NUMEG) = 1
    NUMBER OF LOADING CASES . . . . . (NLCASE) = 1

  MODE OF PROGRAM EXECUTION . . . . . (MODEX) = 1
    .EQ. 0 : VERIFICATION OF INPUT DATA
    .EQ. 1 : SOLUTION OF THE PROBLEM
  NUMBER OF COEFFICIENTS PER BLOCK . . . . . (ISTOTE) = 32
    .EQ. 0 : CALCULATED BY DEFAULT BY PROGRAM BLOCKS
  
```

1 NODAL POINT INFORMATION:

GIVEN NODES		BOUNDARY CONDITIONS				NODAL COORDINATES			PITCH C	
NUMBER	U	V	W	XX	YY	ZZ	X	Y	Z	
1	0	0	0	1	1	1	-.120000E+02	.300000E+02	-.120000E+02	0
2	0	0	0	1	1	1	.120000E+02	.300000E+02	-.120000E+02	0
3	0	0	0	1	1	1	.120000E+02	.300000E+02	.120000E+02	0
4	0	0	0	1	1	1	-.120000E+02	.300000E+02	.120000E+02	0
5	1	1	1	1	1	1	-.200000E+02	.000000E+00	-.200000E+02	0
6	1	1	1	1	1	1	.200000E+02	.000000E+00	-.200000E+02	0
7	1	1	1	1	1	1	.200000E+02	.000000E+00	.200000E+02	0
8	1	1	1	1	1	1	-.200000E+02	.000000E+00	.200000E+02	0
1 NODAL POINT INFORMATION:										

PROGRAM ONE ENGLISH OUTPUT (SPACE TRUSS)

GENERATED NODES				NODAL COORDINATES					
NODE BOUNDARY CONDITIONS									
NUMBER	U	V	W	XX	YY	ZZ	X	Y	Z
1	0	0	0	1	1	1	-1200000E+02	3000000E+02	-1200000E+02
2	0	0	0	1	1	1	1200000E+02	3000000E+02	-1200000E+02
3	0	0	0	1	1	1	1200000E+02	3000000E+02	1200000E+02
4	0	0	0	1	1	1	-1200000E+02	3000000E+02	1200000E+02
5	1	1	1	1	1	1	-2000000E+02	0000000E+00	-2000000E+02
6	1	1	1	1	1	1	2000000E+02	0000000E+00	-2000000E+02
7	1	1	1	1	1	1	2000000E+02	0000000E+00	2000000E+02
8	1	1	1	1	1	1	-2000000E+02	0000000E+00	2000000E+02

1 NODAL POINT INFORMATION:

NODE NUMBER	EQUATION NUMBERS				XX	YY	ZZ
	U	V	W	W			
1	1	2	3	0	0	0	
2	4	5	6	0	0	0	
3	7	8	9	0	0	0	
4	10	11	12	0	0	0	
5	0	0	0	0	0	0	
6	0	0	0	0	0	0	
7	0	0	0	0	0	0	
8	0	0	0	0	0	0	

```

1 TEST SPACE TRUSS NO. 4 (TESTS 3-D CAPABILITY AND AUTO. ELEMENT GENER. )
  P A R A M E T R E S   D E   C O N T R O L E :
  NOMBRE DE POINTS NODAUX . . . . . (NUMNP) = 8
  NOMBRE DE DEGRES DE LIBERTES PAR NOEUD . . . . . (NDOF) = 3
  NOMBRE DE GROUPES D ELEMENT . . . . . (NUMEG) = 1
  NOMBRE DE CAS DE CHARGEMENT . . . . . (NLCASE) = 1

  MODE D EXECUTION DU PROGRAMME . . . . . (MODEX) = 1
  .EQ. 0 : VERIFICATION DES DONNEES SEULEMENT
  .EQ. 1 : SOLUTION DU PROBLEME
  NOMBRE DES TERMES DE LA MATRICE PAR BLOC. . . . . (ISTOTE) = 32
  .EQ. 0 : PAR DEFALT CALCULE PAR LE PROGRAMME BLOCKS
  
```

1 D O N N E S D E S N O E U D S :

NOEUDS DONNES							COORDONNEES DES NOEUDS			PAS COO
NOEUD CONDITIONS AUX LIMITES							X	Y	Z	
NUMERO	U	V	W	XX	YY	ZZ				
1	0	0	0	1	1	1	-.120000E+02	.300000E+02	-.120000E+02	0
2	0	0	0	1	1	1	.120000E+02	.300000E+02	-.120000E+02	0
3	0	0	0	1	1	1	.120000E+02	.300000E+02	.120000E+02	0
4	0	0	0	1	1	1	-.120000E+02	.300000E+02	.120000E+02	0
5	1	1	1	1	1	1	-.200000E+02	.000000E+00	-.200000E+02	0
6	1	1	1	1	1	1	.200000E+02	.000000E+00	-.200000E+02	0
7	1	1	1	1	1	1	.200000E+02	.000000E+00	.200000E+02	0
8	1	1	1	1	1	1	-.200000E+02	.000000E+00	.200000E+02	0
I DONNES DES NOEUDS :										

1 D O N N E S D E S N O E U D S :

PROGRAM ONE OUTPUT (SPACE TRUSS)

NOEUDS GENERES				COORDONNEES DES NOEUDS			
NOEUD CONDITIONS AUX LIMITES							
NUMERO	U	V	W	XX	YY	ZZ	
1	0	0	0	1	1	1	
2	0	0	0	1	1	1	
3	0	0	0	1	1	1	
4	0	0	0	1	1	1	
5	1	1	1	1	1	1	
6	1	1	1	1	1	1	
7	1	1	1	1	1	1	
8	1	1	1	1	1	1	
1 D O N N E S D E S N O E U D S :				X	Y	Z	
				-.120000E+02	.300000E+02	-.120000E+02	
				.120000E+02	.300000E+02	-.120000E+02	
				.120000E+02	.300000E+02	.120000E+02	
				-.120000E+02	.300000E+02	.120000E+02	
				-.200000E+02	.000000E+00	-.200000E+02	
				.200000E+02	.000000E+00	-.200000E+02	
				.200000E+02	.000000E+00	.200000E+02	
				-.200000E+02	.000000E+00	.200000E+02	

NUMEROS D EQUATIONS							
NOEUD	U	V	W	XX	YY	ZZ	
1	1	2	3	0	0	0	
2	4	5	6	0	0	0	
3	7	8	9	0	0	0	
4	10	11	12	0	0	0	
5	0	0	0	0	0	0	
6	0	0	0	0	0	0	
7	0	0	0	0	0	0	
8	0	0	0	0	0	0	

PROGRAM TWO ENGLISH OUTPUT (SPACE TRUSS)

1 INPUT FOR ELEMENT GROUPS:

ELEMENT DEFINITION

ELEMENT TYPE (NPAR(1)) . . = 1
 EQ.1 TRUSS ELEMENTS
 EQ.2 UNAVAILABLE ELEMENT
 EQ.3 UNAVAILABLE ELEMENT
 NUMBER OF ELEMENTS. (NPAR(2)) . . = 12

MATERIAL DEFINITION

NUMBER OF DIFFERENT SETS OF MATERIAL
 AND CROSS SECTIONAL CONSTANTS (NPAR(3)) . . = 1

SET YOUNGS CROSS-SECTIONAL

PROGRAM TWO ENGLISH OUTPUT (SPACE TRUSS)

NUMBER	MODULUS E	AREA A
1	.100000E+08	.280000E+00

ELEMENT INFORMATION

ELEMENT NUMBER-N	NODE I	NODE J	MATERIAL J	SET NUMBER
1	1	2	1	1
2	2	3	1	1
3	3	4	1	1
4	4	1	1	1
5	1	8	1	1
6	2	5	1	1
7	3	6	1	1
8	4	7	1	1
9	8	4	1	1
10	5	1	1	1
11	6	2	1	1
12	7	3	1	1

PROGRAM THREE ENGLISH OUTPUT (SPACE TRUSS)

1 L O A D I N G I N F O R M A T I O N :

LOADING CASE NUMBER	NUMBER OF CONCENTRATED LOADS	D.O.F.	LOAD	VALUE
1	1	1	1	-.100000E+02
1	1	2	1	-.120000E+03
1	1	3	1	-.105000E+03
2	2	1	1	-.100000E+02
2	2	2	1	-.100000E+03
2	2	3	1	-.105000E+03
3	3	1	1	-.100000E+02
3	3	2	1	-.100000E+03
3	3	3	1	-.165000E+03
4	4	1	1	-.100000E+02
4	4	2	1	-.120000E+03
4	4	3	1	-.165000E+03

PROGRAM FOUR ENGLISH OUTPUT (SPACE TRUSS)

1 CHARACTERISTICS OF THE SYSTEM OF EQUATIONS:
 - NUMBER OF EQUATIONS (NEQ) = 12
 - NUMBER OF COEFFICIENTS IN THE MATRIX (NWK) = 69
 - MAXIMUM HALF-BANDWIDTH (MA) = 12
 - AVERAGE HALF-BANDWIDTH (MAM) = 6
 - NUMBER OF COEFFICIENTS PER BLOCK . . . (ISTOH) = 16
 - NUMBER OF BLOCKS FOR THE SOLUTION . . (NBLOC) = 5
 - NUMBER OF COLUMNS PER BLOC AND 1ST COUPLED BLOCK

0 BLOCK NUMBERS:
 1 2 3 4 5

0 NUMBER OF COLUMNS PER BLOCK:
 5 3 2 1 1

0 FIRST COUPLED BLOCK:
 1 1 1 1 1

PROGRAM SEVN ENGLISH OUTPUT (SPACE TRUSS)

PAGE: 1

1 LOADING CASE: 1

- DISPLACEMENTS:

NODE	DISPLACEMENT-U	DISPLACEMENT-V	DISPLACEMENT-W
1	7.714370E-04	-2.155660E-03	-8.505670E-03
2	5.828660E-04	8.630920E-04	-7.018990E-03
3	-6.323930E-04	-5.206780E-04	-6.347560E-03
4	-4.895350E-04	-3.908950E-03	-1.019420E-02
5	0.000000E+00	0.000000E+00	0.000000E+00
6	0.000000E+00	0.000000E+00	0.000000E+00
7	0.000000E+00	0.000000E+00	0.000000E+00
8	0.000000E+00	0.000000E+00	0.000000E+00

1 LOADING CASE: 1

- ROTATIONS:

NODE	ROTATION-X	ROTATION-Y	ROTATION-Z
1	0.000000E+00	0.000000E+00	0.000000E+00
2	0.000000E+00	0.000000E+00	0.000000E+00
3	0.000000E+00	0.000000E+00	0.000000E+00
4	0.000000E+00	0.000000E+00	0.000000E+00
5	0.000000E+00	0.000000E+00	0.000000E+00
6	0.000000E+00	0.000000E+00	0.000000E+00
7	0.000000E+00	0.000000E+00	0.000000E+00
8	0.000000E+00	0.000000E+00	0.000000E+00

1 STRESS CALCULATIONS FOR ELEMENT GROUP 1

PROGRAM SEVN ENGLISH OUTPUT (SPACE TRUSS)

ELEMENT NUMBER	FORCE	STRESS
1	-.220000E+02	-.785715E+02
2	.783333E+02	.279762E+03
3	-.166667E+02	-.595238E+02
4	-.197000E+03	-.703571E+03
5	.300962E+03	.107487E+04
6	-.163485E+02	-.583877E+02
7	-.300962E+03	-.107487E+04
8	-.282384E+02	-.100852E+03
9	-.107944E+03	-.385513E+03
10	-.344671E+03	-.123097E+04
11	-.951185E+02	-.339709E+03
12	.109547E+03	.391238E+03

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